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A TAXONOMIC REVISION OF THE CHALCID PARASITES (HYMENOPTERA : CHALCIDOIDEA) ASSOCIATED WITH *OPISINA ARENOSELLA* WALKER (LEPIDOPTERA : XYLORICTIDAE)

T. C. NARENDRAN

Department of Zoology, University of Calicut, Kerala, India 673 635

(*Received 26 April 1985*)

Twenty-one species of chalcid parasites of *Opisina arenosella* Walker in seven families including a new species and five new records are treated taxonomically and individually commented on briefly, with data on type-locality, type-depository, distribution, hosts, synonyms involved etc. A key for the identification of the twenty-one parasites is provided.

(Key words: revision, chalcids, *Opisina arenosella)*

The black-headed caterpillar of the moth *Opisina arenosella* Walker (=*Nephantis serinopa* Meyrick) is a major pest affecting the coconut palms in India, Sri Lanka, Bangaladesh, and Burma. The pest is found mostly in the coastal areas and in less numbers in the interior parts (Narendran *et al.*, 1978). The Chalcidoidea represents a large superfamily of parasitic wasps and as many as 21 species (including a new species) are associated (mostly as primary parasites and a few as secondary parasites) with various immature stages of *O. arenosella*. A few of these chalcids are widely used in various biological control programmes against this pest and a few others are being studied for possible future use as biological control agents. In spite of the importance of these chalcids as natural enemies of *O. arenosella*, our present knowledge about their taxonomy is very incomplete and out of date. Hence herein I give a comprehensive taxonomic treatment of these chalcids. This paper is based on my research carried out for the last one decade in India and partly based on my studies at the British Museum (Natural History), London during 1979—1980.

The following abbreviations are used in this paper : BMNH, British Museum (Natural History), London; USNM, United States National Museum, Washington, D. C.; UM, University Museum, Oxford; ZMU, Zoological Museum of the University of Copenhagen, Copenhagen; NIAS, National Institute of Agricultural Sciences, Tokyo; ELKU, Entomological Laboratory of Kyushu University, Kyushu; CIE, Commonwealth Institute of Entomology, London; BCRI, Biological and Chemical Research Institute, Sydney; TNAU, Tamilnadu Agricultural Uuiversity, Coimbatore; CIBC, Comonwealth Institute of Biological Contol, Bangalore and DZCU, Department of Zoology, University of Calicut.

A. Family CHALCIDIDAE

1. Antrocephalus cariniceps (Cameron), Comb. nov. (Fig. 1)

Coelochalcis cariniceps Cameron, 1911, *Soc. entom.*, 26:4-5; Type-locality : Borneo Type-depository : BMNH; (Type examined) Syn. nov.

Coelochalcis denticollis Cameron, 1911, *Soc. entom.*, 26:5-6; Type-locality : Borneo. Type-depository : BMNH; Type No. 5-256 (Type examined) Syn. nov.

Sabatiella naduganiensis Mani and Dubey *in* Mani *et al.*, 1974, *Mem. Scn. Ent. St. John's Coll.*, 3:21-23, Type-locality: Nilambur (Kerala) : S. India. Type-depository : USNM; (Type examined) Syn. nov.

The general colour of this species is black with scape, pedicel, apices of femora, apices of tibiae and tegulae blackish brown. A deep furrow is present on each side between post-orbital carina and posierior margin of eye. Scapes never touch the front ocellus. Pronotum is bituberculate with prominent tubercles. First gastral tergite has a pair of prominent carinae at its base and these carinae are longer than the space between it. Cameron (1911) described other two species viz. *Stomatoceras transeversus* and *S. cariniaspis*. I have examined the types of both the species at BMNH. While Cameron based his description of the former species on a single female specimen (Type No. 5-262 of BMNH), he based the description of the latter species on two syntypes consisting of a male and female specimens. It is quite possible that the female specimen of *S. transeversus* is the female of *A. cariniceps*. While I found the male specimen (Type No. 5-255a of BMNH) of *S. cariniaspis* is quite conspecific with *A. cariniceps*, the female (Type No. 5-255b) has been found to have a median longitudinal carina on its scutellum and this female may belong to another species.

Hosts: Pupa of *O. arenosella* (New record).

Distribution: INDIA and BORNEO

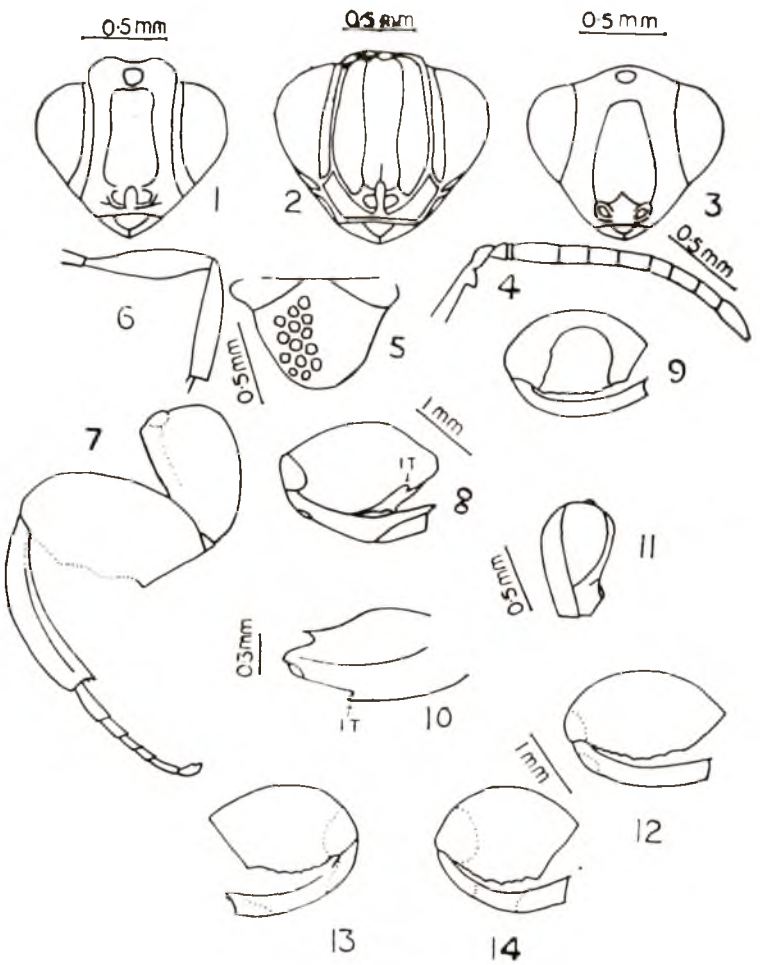
2 Antrocephalus hakonensis (Ashmead) (Fig. 2).

Stomatoceras hakonensis Ashmead, 1904, *J. N. Y. Ent. Soc.* 12:148. Type-locality: JAPAN. Type-depositoty : USNM; (Homotype examined). *Tanania hakonensis:* Habu, 1960, *Bull. Nat. Inst. Agr. Sci Ser. C.* 11:278-282. Subsequent designation. *Antrocephalus hakonensis:* Narendran, 1977, *Entomophaga* 22:297 - current designation.

This species is predominently black with slight reddish or brownish tinge on mandibles, antennae, tegulae and on tarsi. This species has been misidentified by some workers as *Brachymeria tnephantidis* Gahan (Joy and Joseph, 1972). Very often this species has been identified as *Stomatoceras sulcatiscutellum* Girault (1917) or as *Antrocephalus renalis* Waterston (1922). Farooqi and Menon (1973) could not trace either the type or the original description of *S. sulcatiscutellum* and so they suggested that "this species may be regarded as *species dubium*". The type of this species *sulcatiscutellum* is preseet in USNM and I have examined the Homotype through the kindness of Dr. B. D. Burks of USNM. Girault (1917) described this species in one of his series of privately printed papers. In this paper the type-locality of *S. sulcatiscutellum* is given as COIMBATORE, INDIA and host as *Nephantis* sp. In one of my earlier papers I erroneously reported (Narendran, 1976) *Antrocephalus sulcatiscutellum* as synonym of *A. renalis* instead of reporting *vice*

versa. However, the question of synonymy under *A. hakonensis* is not so simple as it may look and several more points are yet to be clarified. Therefore the previously published information under *A. sulcatiscutellum* and *A. renalis* may concern the species I am treating here under *A. hakonensis* and the question of synonymy regarding all these species is currently under study by Dr. Z. Boucek of CIE.

Hosts: Pupa of *O. arenosella*, *Hypsiphyla robusta* Moore and *Contheyla* sp.



Figs. 1—14. 1—2. Species of *Antrocephalus;* 1. *A. carinicceps* (Cameron), head of ♀; 2. *A. hakonensis* (Ashmead), head of ♀; 3—7. *Invreia opisinae* sp. nov. ♂, head; 4. antenna, 5. scutellum, 6. mid leg, 7. hind leg; 8—14. Species of *Brachymeria*. 8. *B. podagrica* (Fabricius), inner aspect of hind femur and tibia, IT. inner tooth; 9. *B. megaspila* (Cameron), hind femur and tibia; 10. *B. lasus* (Walker), hind coxa of ♀, IT. inner tooth; 11. *B. excarinata* Gahan, head profile; 12. *B. nephantidis* Gahan, hind femur & tibia; 13. *B. hime atteviae* Joseph, Narendran & Joy, hind femur & tibia; 14. *B. nosatoi* Habu, hind femur & tibia.

Distribution: Oriental region and JAPAN.

3. **Antrocephalus phaeospilus** Waterston

Antrocephalus phaeospilus Waterston, 1922, *Ind. For. Rec.* 9:72-73. Type. locality ; Bhim Tal, Kumaon (INDIA). Type-depository : BMNH; (Type-examined).

The type is black with tegulae, legs (except fore coxae) brown. Antennae dark sepia coloured with pedicel and second funicular segments brown. The colour of the hind femur is found to vary in specimens collected from *O. arenosella* slightly from brown to black with base and apex rufous and such variation is quite common in this species. No inner tooth is present on the base of hind femur. Fore wing of the type specimen shows brown spot on and behind the marginal vein.

Hosts: Pupa of *O. arenosella* (New record).

Distribution: INDIA

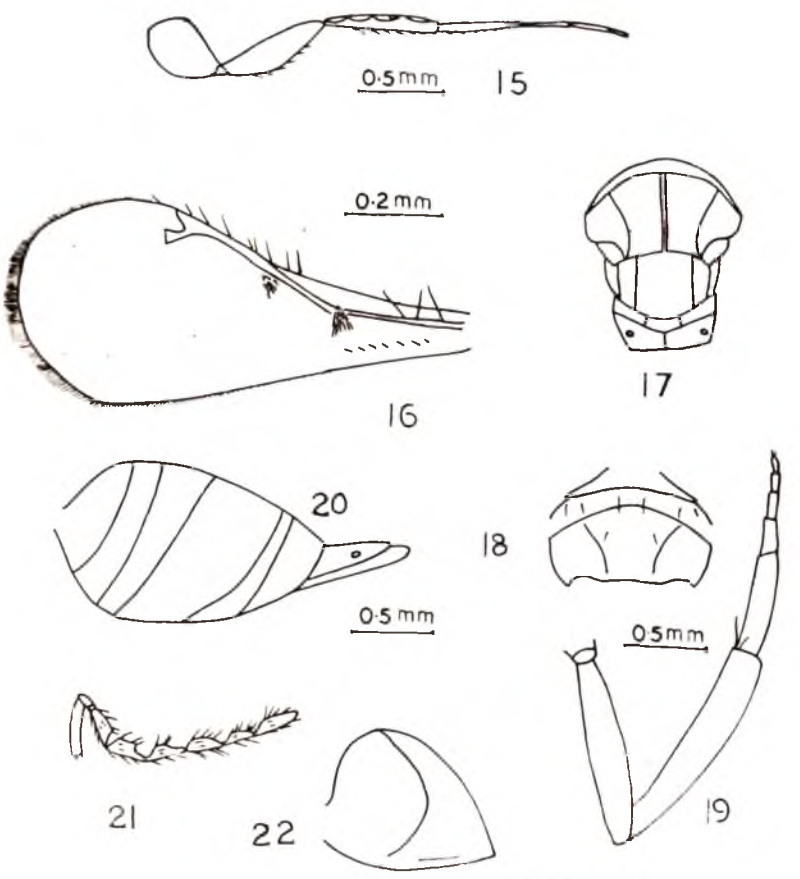


Fig. 15. *Elasmus nephantidis* Rohwar, hind leg; 16. *Trichospilus pupivora* Ferriere, fore wing; 17. *Tetrastichus ayyari* Rohwer, Dorsal view of thorax; 18. *Pediobius imbreus* (Walker), pro & mesoscutum; 19. *Anastatoidea brachartonae* Gahan, hind leg; 20—21. *Eurytoma albotibialis* Ashmead; 20. gaster of ♀; 21. antenna of ♂; 22. *Perilampus microgastris* Ferriere, gaster of ♀.

4. Invreia opisinae sp. nov. (Figs. 3—7)

Male: Length 2.98 to 3.12 mm, Black; pubescence moderately dense. silvery white; wings hyaline, marginal and sigmal brown. Head width subequal to widh of thorax, with distinct pits, interstices of pits smooth, ecarinate on dorsal sides; POL 9.5, OOL 2. Antennae as in Fig. 4, scape with a distinct sharp tooth. Thorax distinctly and sparsely pitted, interstices smooth, ecarinate. Marginal vein 7, SM 28, Stigmal 2. Mid femora as in Fig. 6; hind femora (Fig. 7) on outer side sparsely and minutely pubescent-punctate ventral side with one distinct proximal tooth followed by two lobes. Gaster a little shorter than pronotum, mesoscutum and scutellum and propodeum combined, first tergite strongly microsculptured.

Female: Unknown

Holotype: ♂, INDIA: GUJARAT, Joy, from pupa of *O. arenosella.* 1980.

Paratype: ♂, INDIA: KERALA, C. U. Campus, Narendran *et al.* 11.i.1985. All tyes in DZCU.

Remarks: This species does not come close to any of the species described by Boucek (1951), Erdos (1957), Nikolskaya (1960), Steffan (1962, 1976) and Grissell and Schauff (1981). However it resembles *Invreia ghanii* Habu (Habu, 1970) in geneal appearance but can be easily recognised from it in having the distinct sharp dent on the scape, in having entirely different measurements of antennal segments, in having distinct pits on the dorsal side of head with ecarinate interstices, scapulae densely pitted and in several other features.

Hosts: Pupa of *O. arenosella*

Distribution: GUJARAT (INDIA).

5. Brachymeria (Brachymeria) podagrica (Fabricius) (Fig. 8)

Chalcis podagrica Fabricius, 1787, *Mantissa Insectorum*, 1:272. Type-locality: Tranquibar (INDIA). Type-depository: ZMU: (Homotype examined).

Brachymeria podagrica: Boucek, 1972, *Entomologist's Gazette*, 23:240-242.– Current designation; Joseph, Narendran & Joy, 1973, *Oriental Brachymeria* 1: 96–99.

Chalcis calliphorae Froggatt, 1916, *Qd. agric. J.* 6:177–179. Type-locality: New South Wales, Australia. Type-depository : BCRI?. Syn. nov.

Brachymeria becarii Masi, 1929, *Mem. Soc. Ent. Ital.* 8:142–144. Type-locality: Massaua (Ethiopia). Syn. nov.

Other synonyms (See Boucek, 1972; Habu, 1960) inclue : *Chalcis fonscolombeii* Dufour, *C. alphius* Walker, *C. xerxena* Walker, *C. amenocles* Walker, *C. mansueta* Walker, *C. callipes* Kirby, *C. mikado* Cameron, *C. eccentrica* Cameron, *C. borneanus* Cameron, *C. neglecta* Masi, *C. garutianus* Gunther, and *Brachymeria pulchripes* Holmgren.

Judging from the illustrated description of *C. calliphorae* (the type could not be examined) it is evident that it *B. podagrica.* A similar case is of *B. beccari* which clearly is *B. podagrica.* Among the various species of *Brachymeria* parasitising *O. arenosella,* this is the only species with an inner tooth at the base of hind femur.

Hosts: Mainly parasitic on larval stages of various families of Diptera viz. Calliphoridae, Sarcophagidae, Muscidae and Trypetidae. Among Lepidoptera it attacks various species (For detailed lists of hosts see Burks, 1960; Habu, 1960, 1962; & Joseph *et al,* 1973) of

Psychidae, Yponomeutidae and Lymantriidae. This is a new record for *O. arenosella* (Xyloryctidae).

Distribution: Widely distributed throughout the warmer areas of all continents.

6. Brachymeria (Brachymeria) megaspila (Cameron) (Fig. 9).

Chalcis megaspila Cameron, 1906, *J. Bombay nat. Hist. Soc.* 7:581. Type-locality : Mt. Abu (RAJASTHHN, INDIA).

Brachymeria megaspila: Mani, 1938, *Catalogue Ind. Ins.* 23:56–Current designation: Joseph, Narendran & Joy, 1973, *Oriental Brachymeria,* 1:149-152.

This is a robust species with dense silvery pubescence on the apex of scutellum. Colouration is generally black with parts of legs and tegulae yellow. Hind femur yellow or reddish-yellow with characteristic black patch of varying size in the middle. The species *B. ornatipes* Cameron (1906) described from KASHMIR, INDIA, resembles this species very closely except in having the pubescence not very silvery and the hind femur is quite thicker than that of *megaspila.*

Host: Pupae of *O. arenosella* (New record) and *Eurema* sp.

Distribution: INDIA, VIETNAM and JAVA.

7. Brachymeria (Brachymeria) lasus (Walker) (Fig. 10).

Chalcis lasus Walker, 1841, *Entomologist,* 1:219. Type locality : WEST BENGAL (INDIA). Type-depository : BMNH (Type examined).

Brachymeria lasus Mani, 1937, *Catalogue Ind. Ins.* 23:56–Current designation? Joseph, Narendran & Joy, 1973, *Oriental Brachymeria,* 1:29–36.

Onchochalcis marginata Cameron, 1904, *Entomologsst*, 37:161. Type-locality: INDIA. Type-depository : BMNH: (Type examined) Syn. nov.

Other synonyms (See Joseph *et al*, 1973) include : *Chalcis inclinator* Walker, *C. punctiventris* Cameron and *Chalcis obscurata* Walker.

I examined the type of *Onchochalcis marginata* Cameron and found that it is the same species *B lasus* (Walker). Dr. Z. Boucek of CIE informed me that he had already come to the same conclusion independently. Masi prepared a key (unpublished) to Oreintal and Palearctic (in part) species of *Brachymeria* and Gahan modified this unpublished key. Dr. B. D. Burks of USNM sent this manuscript key to us and in this key the species *B. regina* (Girault) (1915) has been synonymised to *B lasus*. According to Girault's (1915) description, *B. regina* has the scutellum deeply emarginate at apex and such variation is not very common in *B lasus* where the apex of scutellum is round or at the most weakly emerginate.

Hosts: Polyphagous species primarily parasitising pupae of several species of Lepidoptera including *O. arenosella* and secondarily parasitising these lepidopterans through a few species of Diptera and Hymenoptera (For detailed lists of hosts see Habu, 1960, 1962; Narendran & Joseph, 1976, 1977). The CIBC Indian Station (Bangalore) sent this species to Sri Lanka for the control of *O. arenosella* but it was not proved successful against the pest (Rao *et al.*, 1971). However, very recently this species is undergoing reinvestigation as potential gypsy moth parasitoid in USA (Simser & Coppel, 1980).

Distribution: World wide but mostly confined to warmer countries of all continents.

8. Brachymeria (Brachymeria) euploeae (Westwood)

Chalcis (Brachymeria) euploeae Westwood, 1837, *Trans Ent. Soc. Lond.* 11:6. Type-locality : INDIA. Type-depository: UM?. (Homotype examined).

Brachymeria euploeae: Mani, 1938, *Catalogue Ind. Ins.* 23: 55. Joseph, Narendran & Joy, 1973, *Oriental Brachymeria* 1:58-59. *Chalcis hearseyi* var. *xanthoterus* Waterston, 1922, *Ind. For. Rec.* 9:58. Type-locality : Dehra Dun (INDIA). Type-depository : BMNH; (Type examined). Syn. nov.

Joseph *et al.*, (1973) treated *B. hearseyi* var. *xanthoterus* as a distinct species and at the same time reported that according to Boucek it is the same as *B. euploeae.* I examined the type of *B. hearseyi* var. *xanthopterus* and confirmed that it is *B. euploeae.* However I am doubtful of the plesiotype of *B. hearseyi* var. *xanthopterus* on which the redescription of this species is made by Joseph *et al.*, (1973) since there seems to be a complex of species all very closely resembling *B. euploeae* and *B. lasus* and the plesiotype of Joseph *et al.*, (1973) of *B. haerseyi* var. *xanthoyterus* may quite possibly belong to this complex. According to Boucek (in litt., 1972) many authors including Gahan, Ferriere, and Kerrich misidentified *B. euploeae* as *B. lasus* because they did not look for the type material and based their opinion on the misidentified specimens from the Walker Collection present in BMNH. Unlike *B. lasus*, *B. euploeae* has the second tergite of the gaster vaguely punctured, often almost smooth; female gaster short and not distinctly acuminate posteriorly; antenna stoutish and hind coxa without ventro-mesal tooth in female.

Hosts: Polyphagous species primarily parasitising various species of Lepidoptera including pupae of *O. arenosella* and secondarily parasitising these lepidopterans through a few species of Diptera and Hymenoptera (Habu, 1960, 1962; Joy & Joseph, 1973).

Distribution: Mainly Oriental and partly Palearctic.

9. Brachymeria (Brachymeria) excarinata Gahan (Fig. 11)

Brachymeria excarinata Gahan, 1925, *Philipp. Jour. Sci.* 27:90-91. Type-locality: Philippines. Type-depository : USNM; (Homotype examined).

Brachymeria excarinata: Habu, 1960, *Bull. Nat. Inst. Agr. Sci. Ser. C.* 11:201-206; Habu, 1962, *Fauna Japonica:* 61-65; Joseph, Narendran & Joy, 1973, *Oriental Brachymeria* 1:163-166.

Unlike the typical features of the family Chalcididae, this species has slight metallic reflection on the pronotum of some populations. This species resmbles *B. nephantidis* very closely except for the absence of post-orbital carina. In some of the populations of this species, the black colour at the base of hind tibia is not deep. I doubt that the species *B. apantelesi* Risbec, *B excarinata plutellae* Joseph, Narendran & Joy and *B. excarinata* Gahan are all forms or variations of *Brachymeria plutellophaga* (Girault) (Girault 1921.)

Hosts: Primarily parasitic on pupae of *O. arenosella, Cnaphalocrocis medinalis* Guenee, *Plutella maculipennis* Curtis, *Grapholitha molesta* Busck. *Campolechia metagramma* Meyrick, *Parnara mathias*

(F.), *Ecphoropsis perdistinctus* (Viereck), *Diaphania indica* Saud, and *Homona* sp. (Habu, 1960, 1962: Joseph *et al.*, 1973).

Distribution: Oriental region and Egypt.

10. Brachymeria (Brachymeria) nephantidis Gahan (Fig. 12).

Brachymeria nephantidis Gahan, 1930, *Proc. U. S. N. Mus.* 2831:5. Type-locality COIMBATORE (INDIA). Type-depository: USNM; (Metatype examined).

Brachymeria nephantidis: Joseph Narendran & Joy, 1973, *Oriental Brachymeria* 1:75-77.

I examined a metatype of this species present in the collections of TNAU in addition to several hundreds of specimens collected by me from the coconut growing tracts of KERALA. The species resembles *B. excraniata* in general appearance but can be easily distinguished from that species in having a distinct postorbital carinae.

Hosts: Primarily parasitic on the pupae of *O. arenosella* and rarely parasitic as a secondary parasitoid of the same pest through the braconid *Apanteles taragamae* Vireck and through the dipteran *Stomatomyia bezziana* Baranoff.

Distribution: INDIA and SRI LANKA.

11. Brachymeria (Brachymeria) hime atteviae Joseph, Narendran & Joy (Fig. 13).

Brachymeria hime atteviae Joseph, Narendran & Joy, 1972, *Ind. Forestor* 98:556-558. Type-locality : INDIA. Type-depository : FRI: (Type examined).

Brachymeria hime atteviae: Joseph, Narendran & Joy, 1973, *Oriental Brachymeria* 1:123-126.

Morphologically this subspecies resembles very closely the nominate subspecies except for a few very minor differences pointed out by Joseph *et al*, (1973). It is possible that this species may be a sibling species which resembles the species *B. hime* Habu (1960). However, it is difficult to conclude about this possibility before carrying out cross-breeding experiments. This species *(B. hime atteviae)* resembles *B. nephantidis* also in genral apearance but can be easily distinguished from that species in having the base of hind tibia yellow or reddish-yellow instead of black or brown as in *B. nephantidis*.

Hosts: Pupae of *O. arenosella*, *Atteva fabrieiella* Swederest, *Hapalia machaeralis* Walker and *Corcyra cephalonica* Staint.

Distribution: Widely distributed in northern and southern India.

12. Brachymeria (Neobrachymeria) nosatoi Habu (Fig. 14)

Brachymeria (Neobrachymeria) nosatoi Habu, 1966, *Kontyu* 34:25-28. Type-locality : Ishigaki is (JAPAN). Type-depository : ELKU *Brachymeria (Neobrachymeria) nosatoi:* Joseph, Narendran and Joy, 1973, 1:193-196.

During the year 1971 Dr. A. Habu of Nias compared some specimens of this species sent to him from the Department of Zoology, University of Calicut for comparison with the types and for confirmation. He compared them with two paratypes preserved at NIAS and could not find any difference in the female except the smaller apical yellow patch of hind femora. According to him the male, however, has a shorter scape of the antennae in the Indian forms. This species resembles *B. hime atteviae* in general appearance but can be easily distinguished by the long gaster and

long epipygium (subgeneric feature) in female. However, the males of these two species are difficult to separate inspite of the presence of relatively longer inter-antennal projection in both male and female of *B. (N.) nosatoi* In the subgenus *Neobrachymeria*, the antennal insertion is at the level of the ventral margin of compound eyes. However, I consider that this character of antennal insertion must be taken with some reservation since some species of the subgenus *Brachymeria* including *B. hime atteviae* show the antennal insertion very near the ventral margin of compound eyes.

Host: Pupae of *O. arenosella*, *Dioryctria spelendidella* Herrichschaffer and *Evetria cristata* Walsingham (Joseph *et al.*, 1973) and *Pectinophora gossypiella* S. (Narendran & Joseph, 1975).

Distribution: India, Japan and Papua New Guinea.

B. Family ELASMIDAE

13. Elasmus nephantidis Rohwer (Fig. 15)

Elasmus nephantidis Rohwer, 1921, *Ann. Mag. Nat. Hist.* 12:123. Type-locality Coimbatore (India). Type-depository: USNM? *Elasmus nephantidis:* Ferriere, 1930. *Bull. ent. Res.* 20:415

Specimens of this species are in the BMNH and several specimens have been collected by me from India. According to Ferriere (1930a) the only other species with which this could be confused is *E. albomaculatus* Gahan which has also the same yellow spots on mesoscutum and from that species *E. nephantidis* differs mainly in having a brown or brownish-red colour at the base of the gaster below.

Hosts: Prepupae of *O. arenosella.*

Distribution: INDIA, SRI LANKA and MALAYA.

C. Family EULOPHIDAE

14. Trichospilus pupivora Ferriere (Fig. 16)

Trichospilus pupivora Ferriere, 1930b *Bull ent. Res.* 21:358–359. Type-locality Cochin (India). Type-depository: BMNH *Trichospilus pupivora*: Boucek, 1976, *Bull. ent. Res.* 65:673–676.

This species can be confused with another species viz. *T. diatraeae* described by Cherian and Margabandhu (1942). However *T. diatraeae* differs from *T. pupivora* in having the fore wing only with infumate spots covered with loose dark hairs instead of distinct tuft of black hairs as in the case of *T. pupivora*

Hosts: This is a gregarious pupal parasite of various lepidopterans including *O. arenosella* (mostly primary and occasionally secondary through tachinids (see Boucek, 1976, for detailed lists of hosts).

Distribution: India, Sri Lanka, West Malaysia, Java, Papua New Ginea, New Britain and Mauritius.

15. Tetrastichus ayyari Rohwer (Fig. 17)

Tetrastichus ayyari Rohwer, 1921, *Ann. Mag. Nat. Hist.* 7:128 Type-locality: Coimbatore (India). Type-depository: USNM

Various workers reported this species under various names as parasite of *O. arenosella.* Therefore the previously published information under various names may concern the species I am treating here under *T. ayyari* and the question of synonyms involved is currently under study by Dr. Boucek of CIE. The species is generally black in colour with fore coxae and all femora yellowish-brown.

Hosts: Pupae of *O. arenosella* (Kurian, 1963; Ali & Subramaniam, 1972), *Chilo infuscatellus* Snellen, *C. suppressalis*

(Walker), *C. auricilia* Dudgeon, *Sesamia inferns* (Walker) (Rotschild, 1970); and *Argyris* sp. (Mani and Kurian, (1953), *Pyrausta machaeralis* Walker (Patil & Thontadarya, 1983).

Distribution: India, Sri Lanka and Malasia.

16 Pediobius imbreus (Walker) (Fig. 18)

Entedon (Pediobius) imbreus Walker 1846a, *Ann. Mag. Nat. Hist.* 17:184–185. Type-locality : India. Type-depository: BMNH. *Pediobius imbreus*: Ashmed, 1904, *Mem. Carnegie Mus.* 1:384 (Current designation); Gahan, 1930, *Proc. U. S. N. Mus.* 77:9. Synonyms (Kerrich, 1973) include: *Pleurotropis detrimentosus* Gahan.

This species closely resembles *P. parvulus* originally described by Ferriere (1933) as primary and secondary parasite of *Promecotheca* sp. infesting coconut palms in Java. However, *P. parulus* differs from *P. imbreus* in having sides of upper face with weak reticulation, sides of pronotal collar less contracted, mesoscutum less angulate, antenna with funicular segment hardly longer than broad and fore wing posteriorly exceeding the apex of gaster.

Hosts: According to Ferriere (1933) the type of *P. detrimentosus* Gahan had been reared in India from the cocoons of Bethylid *Perisierola* infesting *O. arenosella* and the same species is also secondarily parasitic on *Promecotheca* sp., on *Dimmockia javanica* (Paine) and larva of *Plesispa reichei* Sharp.

Distribution: India and Java.

D. Family EUPELMIDAE

17. Anastatoidae brachartonae Gahan (Fig. 19)

Anastatoidea brachartonae Gahan, 1927, *Proc. U. S. N. Mus.* 71:1–39. Type-locality: Java. Type-depository : USNM *Anastatoidea brachartonae:* Joy & Joseph 1976, *Entomon* 1:199–200.

Body is generally black with metalic green and blue reflections. Basitarsal segments of mid and hind legs are enlarged. Hind tibiae have two uneqal spurs on each leg. Ovipositor is a little longer than the gaster.

Hosts: Primarily parasitic on the prepupae of *O. arenosella*, *Brachartona catoxantha* Hampson and secondarily parasitic on *B. catoxantha* through *Degeeria albiceps* Macquart, *Ptychomyia remorta* Aldrich and cocoons of *Apanteles* sp.

Distribution: India and Java.

E. Family EURYTOMIDAE

18. Eurytoma albotibialis Ashmead (Fig. 20 & 21)

Eurytoma albotibialis Ashmed, 1905, *Proc. U. S. N. Mus.* 28:965. Type-locality: Philippines. Type-depository: USNM

This species is generally robust with its hind tibia yellow. The species *Eurytoma pallidiscapus* Cameron may fall under synonymy with *E. albotibialis* Ashmead (Narendran, 1984).

Hosts: Secondarily parasitic on *O. arenosella* through its bethylid and braconid parasites.

Distribution: Indian subcontinent and Philippines.

19. Eurytoma braconidis Ferriere

Eurytoma braconidis Ferriere, 1929, *Bull. ent. Res.* 20:256, ♀♂ Type-locality: Syntypes from Uganda, Tanganyika & Sudan. Types (Syntypes) depository: BMNH.

This is a smaller species compared to *E. albotibialis*. Otherwise it resembles *E. albotibialis* except for its black hind tibiae (in *E. albotibialis* it is yellow).

Hosts: Secondarily parasitic on *O. arenosella* through its braconid parasites.

Distribution: India, Uganda, Tanganyika and Sudan

F. Family PTEROMALIDAE

20. Perilampus microgastris Ferriere (Fig. 22)

Perilampus microgastris Ferriere, 1930b, *Bull. ent. Res.* 21:353–354. Syntypes–localities : India, Malay Penisula and Java. Type–depository : BMNH: (Syntypes examined).

Ferriere (1930b) stated that "the types of new species are deposited in the British Museum". However he did not specify the type–locality since the material came from different localities and from different countries. I examined two syntypes of these species. The body of this species is generally black with parts of legs metalic blue. Parts of antennae are brown or brownish–red.

Hosts: Secondarily parasitic on *O. arenosella* through *Apanteles taragamae* Viereck and on *Tirathaba* sp. through *Apanteles* sp.Other hosts include : *Microgaster indicus* Wilkinson, *Apanteles machaeralis* Wilkinson, and larva of *Lamprosema diemenalis* Guenee.

G. Family TRICHOGRAMMATIDAE

21. Trichogramma chilonis Ishii

Trichogramma chilonis Ishii, 1941, Kontyu 14: 169–176. Syntypes–localities: Philippines, JAPAN and TAIWAN. Type–depository : NIAS.

Trichogramma chilonis: Nagarkatti and Nagaraja, 1979, Oriental Ins. 13: 115–118.

Synonyms include (Nagarkatti & Nagaraja, 1979) : *Trichogramma confusum* Viggiani (1976).

Several workers misidentified this species as *T. minutum* Riley, *T. australicum* Girault and as *T. confusum* Viggiani for a long time until Nagarkatti and Nagaraja (1979) published about the synonymy involved. The body of this species is yellow with gaster and mesoscutum black. Antennal hairs are somewhat sharply pointing and moderately long. Dorsal expansion of gonobase bear lateral lobs.

Hosts: Eggs of several species of Lepidoptera including *O. arenosella* (See Nagarkatti & Nagaraja, 1979, for detailed list of hosts).

Distribution : Inida, Sri Lanka, Thailand, Phillipines, Japan and Taiwan (Formosa).

KEY TO SPECIES OF CHALCIDS ASSOCIATED WITH *OPISINA ARENOSELLA* WALKER.

1. Tarsi 3 segmented; wing disc with setae arranged in radiating rows .... *Trichogramma chilonis* Ishii
— Tarsi 4 or 5 segmented; setae on wings arranged differently..... 2
2. Hind coxa greatly enlarged, flattened, plate like (Fig. 15); tarsi 4 segmented.... .....*Elasmus nephantidis* Rohwer
— Hind coxa not as above; tarsi 4 or 5 segmented..... 3
3. Hind femur greatly swollen, its ventral margin toothed..... 4
— Hind femur not swollen, its ventral margin not toothed..... 15
4. Hind femur with rather irregular teeth (Fig. 13) on its ventral margin; end of hind tibia obliquely truncated..... 5
— Hind femur with a comb of fine minute teeth (Fig. 7) on its ventral margin; end of hind tibia almost straightly truncated..... 12
5. Hind tibia completely yellow; hind femur yellow or reddish-yellow, usually with a black patch in the middle..... .....*Brachymeria megaspila* (Cameron)
— Hind tibia and hind femur without such pattern of colouration..... 6

6. Hind tibia yellow with the base black.... 7
— Hind tibia colour not as above..... 8

7. Second tergite of gaster completely and minutely punctate; female gaster oval; each coxa of hind legs with an inner ventromesal tooth..... .....*Brachymeria lasus* (Walker)

— Second tergite of gaster smooth or shagreened with a single row of indistinct punctures on baso-dorsal side; female with gaster subglobose; and, without ventromesal tooth on hind coxa....*Brachymeria ceylonicae* (Westwood

8. Gaster well elongated and strongly acuminate at apex in female; antennae inserted at level of ventral margin of compound eyes..... .....*Brachymeria nosatoi* Habu

— Gaster not well elongated; antennae inserted above level of ventral margin of compound eyes..... 9

9. Post-orbital carina absent..... .....*Brachymeria excarinata* Gahan

— Post-orbital carina present..... 10

10. Hind femur with a distinct inner tooth (Fig. 8) at base, hind femur usually reddish-brown or reddish-black with apex yellow..... .....*Brachymeria podagrica* (Fabricius)

— Hind femur without an inner tooth at base; hind femur black with apex yellow..... 11

11. Hind tibia black with sub-basal and apical yellow colour..... .....*Brachymeria nephantidis* Gahan

— Hind tibia yellow with a median black band.....*Brachymeria hime atteviae* Joseph, Narendran and Joy

12. Marginal vein of fore wing touches wing border and distinctly continues into short post-marginal vein..... 13

— Marginal vein narrowly separate from wing border, parallel to it; post-marginal reduced or absent..... .....*Invreia opisinae* sp. nov.

13. Auricular carina continuous with pre-orbital carina (Fig. 2); scutellum with a median furrow..... ....*Antrocephalus hakonensis* (Ashmead)

— Pre orbital carina not as above; scutellum without a median furrow..... 14

14. Pre-orbital carina predominently raised (Fig. 1), not straight on the vertex; apex of scutellum faintly emarginate.. .....*Antrocephalus cariniceps* (Cameron)

— Pre-orbital carina not so predominently raised and straight on the vertex; apex of scutellum more distinctly bilobed.. ....*Antrocephalus phaeospilus* Waterston

15. Hind tarsi 4 segmented..... 16
— Hind tarsi 5 segmented..... 18

16. Fore wing with two tufts of black hair (Fig. 16)..... .....*Trichospilus pupivora* Ferriere

— Fore wing without such tufts of hair.... 17

17. Scutellum (Fig. 17) with two submedian longitudinal lines; mesoscutum with a complete median line (Fig. 17); gaster sessile.....*Tetrastichus ayyari* Rohwar

— Scutellum and mesocscutum (Fig. 18) without such lines or grooves; gaster petiolate.....*Pediobius imbrens* Walker

18. Pronotum fused with prepectus; dorsum of gaster (Fig. 22) occupied largely by partly fused basal tergites, gaster more or less triangular in lateral view .....*Perilampus microgastris* Ferriere

— Pronotum and gaster not as above 19

19. Mid and hind (Fig. 19) basitarsal segments and tibial spurs of mid and hind legs (Fig. 19) enlarged; pronotum dorsally not rectangular..... .....*Anastatoidea brachartonae* Gahan

— Mid and hind basitarsal segments and tibial spurs normal; pronotum large and rectangular; gaster not petiolate in female (Fig. 20); antennae of males (Fig. 21) are plumose..... 20

20. Hind tibia yellow..... ..... *Eurytoma albotibialis* Ashmead

— Hind tibia black with base and apex pale yellow..... .....*Eurytoma braconidis* Ferriere

For practical reasons the species are here arranged family vice.

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KARYOLOGY OF TETTIGONIDS (CLASS : INSECTA): CHROMOSOMES AND CONSTITUTIVE HETEROCHROMATIN IN *EUHEXACENTRUS ANNULICORNIS* STOL (SUBFAM LISTROSCELINAE)

N. V. ASWATHANARAYANA & S. K. ASHWATH

Department of Zoology, University of Mysore, Manasa Gangotri, Mysore, India 570 006

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The karyotype of *Euhexacentrus annulicornis* is presented for the first time. The male diploid number is 12 (10A + XY). This is the lowest number so far reported in tettigonids. All the chromosomes are metacentric. A pair of autosomes bear secondary constrictions. Distribution of constitutive heterochromatin is described.

(Key words: Euhexacentrus annulicornis tettigonid, chromosomes, constitutive heterochromatin)

INTRODUCTION

The chromosomes of the longhorned grasshoppers (Fam : Tettigonidae) are known to be generally large and thus amenable for accurate karyotype analysis. The chromosome information of this highly diverse group remains limited compared to shorthorned grasshoppers in the group Acrididae. The main reason may be, the difficulties encountered to collect them because of their adaptive behaviour

This group has a wide range of chromosome numbers from 16–39 (FERREIRA, 1977; UESHIMA & RENTZ, 1979). The great majority of the species have *XX:XO* type of sex chromosome mechanism. But a few species have *XX:XY* type and also complicated type of X_1 X_2 Y in males (DAVE, 1965: UESHIMA & RENTZ, 1979).

Though chromosomal survey on the Indian tettigonids was started as early as 1938 by ASANA *et al.*, their karyology is still poor. After a gap of nearly three decades chromosomes of a total of about 13 species are known to-date (DAVE, 1965; KACKER & SINGH, 1978; KUMARASWAMY & RAJASEKARASETTY, 1979). This prompted us to take up the karyology of tettigonids. In the present study the chromosomes of *Euhexacentrus annulicorins* (Subfam : Listroscelinae) which has the lowest chromosome number of 12 in the males is described for the first time.

MATERIALS AND METHODS

Two male specimens of *Euhexacentrus annulicornis* Stol, were collected in the enviorns of Mysore, India. Testes and hepatic caeca were utilised for chromosome analysis. But testes did not yield good preparations and hence chromosomes of only the hepatic caeca have been presented applying the modified air-dry-Giemsa technique of IMAI *et al.* (1977) and C-banding method of SHAW *et al.* (1976).

OBSERVATIONS

This species has a male count of 12 chromosomes ($10A + XY$). All the members of the complement are metacentric (Fig. 1). The karyotype consists

of 4 pairs of large (No. 1–4) and a small pair of metacentric (No. 5) autosomes. A pair of autosomes possesses secondary contributions. The *X* chromosome is slightly larger than the second largest autosome and the *Y* chromosome is the smallest element of the complement (Fig. 1a).

The constitutive heterochromatin is distributed in the procentric, interstitial and telomeric regions of most of the chromosomes. The *X* chromosome is the only chromosome with large centromeric band as well as larger interstitial bands in both the arms. The *Y* chromosome is uniformly dark (Fig. 2).

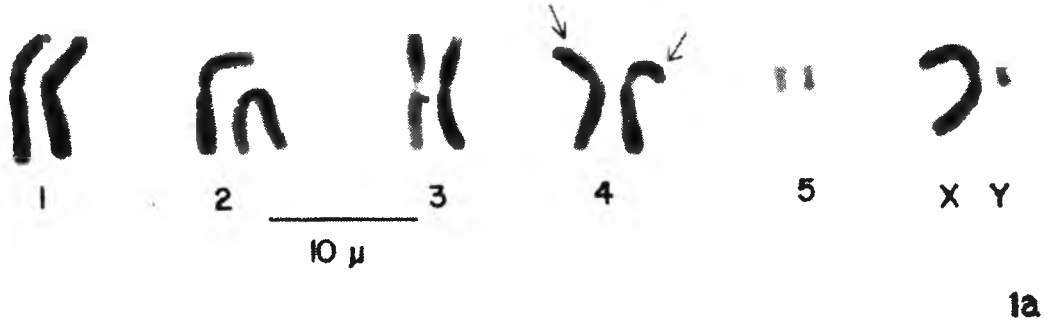
DISCUSSION

The chromosomal studies on the longhorned grasshoppers have been negligible in general and of the Indian species in particular. In the subfamily Listroscelinae, HAREYAMA (1937) reported a male diploid number of 33 in *Hexacentrus japonicus* but the morphology of the chromosomes is not clearly described. Later ASANA *et al.* (1938) studied two more species of this genus viz., *H. mundus* and *H. annulicornis* with a chromosome number of 31 (30+*X*) in both the species with all telocentric chromosomes except the *X* chromosomes having a submedian constriction. In *Yorkiella* sp. 1 and 2 FERREIRA (1969) described $2n=31$ with all acrocentric chromosomes and a metacentric *X*. Interestingly, WHILE *et al.* (1967) recorded a neo-*XY* sex chromosome mechanism in *Y. picta* ($2n=18+XY$). FERREIRA (1969) reported a diploid number of 16 in *Polichne parvicauda* with a neo–*XY* mechanism.

The sex chromosome mechanism in majority of the tettigonids is of *XX* : *XO* type. However, the males in a few species show *XY* or X_1 X_2 *Y* system (UESHIMA & RENTZ, 1979). WHITE (1973) is of the opinion that the *XO* condition in males is original and all the other types of sex mechanism are derivatives and recent in an evolutionary sense. The *XX* : *XY* mechanism is achieved by the centric fusions between the acrocentric *X* and an acrocentric autosome which forms a "neo–*X*" and the original homologue of the fused autosome constitutes a neo–*Y*. This neo–*XY* system can undergo further conversion into X_1 X_2 *Y* by a *Y*–autosome fusion.

Euhexacentrus annulicornis of the present study is unique among tettigonids in that it is the only species known to have: 1) the lowest diploid number of 12 in the males, and 2) all metacentric chromosomes in the karyotype including *X* and *Y*. Regarding the reduction in the chromosome number to 12 in the present species, it might have followed the mechanism of autosomal fusions and a centric fusion between the *X* chromosome and an autosome to produce the neo–*XY* systen as in *Polichne parvicauda* with $2n = 16$ (FERREIRA, 1969). Since no suitable meiotic stages were available the origin of *Y* chromosome cannot be explained with certainty as the observations are confined only to the somatic chromosomes of the hepatic caeca. However, the unpaired darkly stained smallest metacentric chromosome in the C–band metaphases is identified as the *Y* chromosome as in eutherian mammals.

Based on the karyotype structure with all metacentric chromosomes and C–positive *Y* chromosome the authors consider that *Euhexacentrus annulicornis* is more advanced than any other species



1a

Fig. 1. Male somatic complement from gut caeca. 1a. Karyotype showing 4 pairs of large (No. 1—4) one small pair of metacentric autosomes and sex chromosomes. 2. C-banded metaphase of the male. Note the distribution of constitutive heterochrochromatin. *Y* Chromosome is uniformly stained. Arrow indicates the secondary constriction.

of tettigonids so far described. However, meiotic studies have to be made to confirm the neo-*XY* mechanism.

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TRIOXYS PENICULATUS (HYM., APHIDIIDAE), A NEW PARASITOID OF *CERVAPHIS SCHOUTENIAE* V. D. G. IN INDIA

BASANT K. AGARWALA, J. L. SAHA & S. K. MAHAPATRA

Department of Life Science, Calcutta Univefsity Post Graduate Centre
Agartala, India 799 004

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Trioxys peniculatus n. sp. parasitizing *Cervaphis schouteniae* V. d. G. in Tripura, Northeast India is described.

(Key words: aphidiid parasitoid, new species)

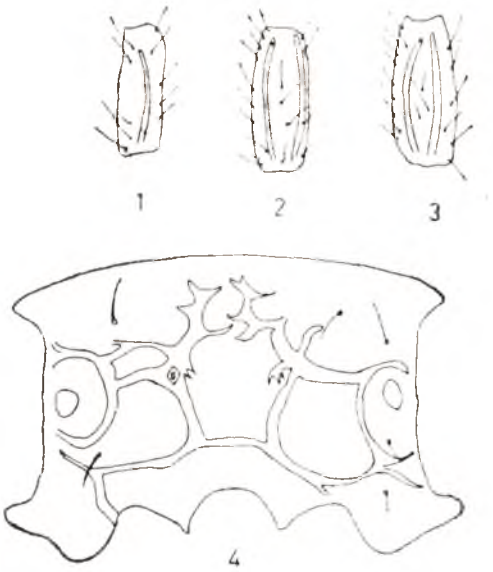
The aphid subfamily Greenideinae is associated with a peculiar group of prevalently specific aphidiid parasitoids. All the recorded hosts belong to the tribe Greenideni (cf. Mackauer, 1968; Stary & Ghosh, 1983).

The present account brings a description of a new aphidiid parasitoid species reared from *Cervaphis schouteniae* V. d. G. It seems to be the first parasitoid record in the tribe Cervaphidini that is represented by 9 genera and 18-20 species in the world (Ghosh, 1982).

Trioxys (Trioxys) peniculatus, n. sp.

The new species is easily distinguishable from the other oriental congeners by the shape of ovipositor sheaths and accessory prongs in the female and by the host range.

Female : Head sparsely haired. Eyes medium sized. Gena equal to 1/5 of length. Tentorial index 0.3. Facial region with two long hairs. Antennae 11-segmented, slightly thickened to the apex. Flagellar segment 1 (=F_1) 3.2 times as long as wide, with single rhinarium, the hairs slightly longer than half of the segment diameter (Fig. 1). F_4 2.33 times as long as wide, with two rhinaria (Fig. 2). F_5 2.1 times as long as wide, wider than F_4, with two rhinaria (Fig. 3).



Trioxys penicu atus sp. nov. : Female:
Fig. 1–3 : Flagellar segments 1, 4 and 5
Fig. 4 : Propodeum.

Mesonotum with sparse hairs. Propodeum areolated: central areola irregular at the anterior portion (Fig. 4). Forewing: Pterostigma almost 3 times as long as wide; metacarpus short, equal to about 1/3 of pterostigmal length. Radial vein about 2.5 times as long as the width of pterostigma (Fig. 5).

pale brown, laterally darkened. Ovipositor sheaths dark brown, prongs mostly yellow.

Measurements of the holotype (in mm):

Body length; 1.5; head width, 0.34; facialline, 0.31; interocular line, 0.23; transfacialline, 0.13; tentorio-ocular line, 0.13;

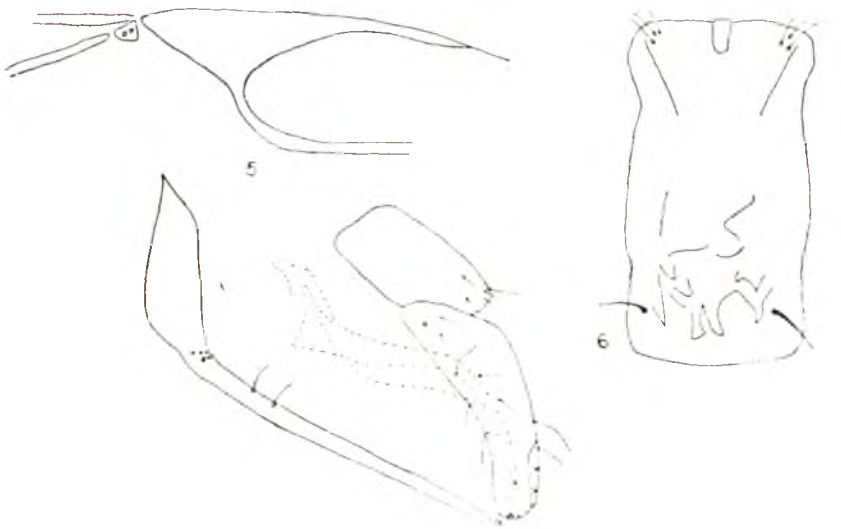


Fig. 5 : Part of venation in forewing; Fig. 6 : Tergite 1; Fig. 7 : Genitalia.

Tergite 1 (Fig. 6) about twice as long as broad across spiracles, primary tubercles situated little beyond the middle, distinct.

Genitalia (Fig. 7) : Prongs strong, straight, two hairs on the dorsal side, with 1 apically dilated apical bristle; antero-lateral margin of ovipositor sheaths provided with 3 distinct cells.

Colouration: Head dark brown; mandibles, scape, pedicel, F_1, F_2 and part of F_3 pale brown, the rest of flagellar segments brown. Thorax brown; wings hyaline, venation light brown. Legs pale brown except brown femur. Abdomen

intertentorial line, 0.09; gena, 0.05; socket diameter, 0.04; socket ocular diameter, 0.03; vertical eye diameter, 0.18; longitudinal eye diameter, 0.09; mandible 0.09; F_1 length, 0.09; breadth 0.03; F_4 length, 0.08; breadth, 0.03; F_5 length, 0.07; breadth, 0.03. Pterostigmal length, 0.20; width, 0.07; radial vein, 0.19; tergite I, length, 0.19; breadth 0.09.

Male: Antennae 13-segmented. Colouration similar but darker in the female.

Material: Cervaphis schouteniae V. d. Goot. -Agartala, Tripura, India, 17. viii. 1983 on *Microcos peniculats* holotype ♀; 1♀, 2♂♂ paratypes (leg. Agarwala

and Mahapatra). Deposition : Deptt. of Life Science, Calcuta University P. G. Centre, Agartala.

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BIOLOGY OF *CASSIDA ENERVIS* BOH. (COLEOPTERA : CHRYSOMELIDAE : CASSIDINAE)—A SERIOUS PEST ON *CELOSIA ARGENTEA*, AN ORNAMENTAL PLANT

*J. P. SINGH, H. S. ROSE & SANGITA

Department of Zoology, Punjabi University, Patiala, India - 147 002

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The biology of *Cassida enervis* Boh. was studied in the laboratory (at 28± 2°C and 70—80% R H) and under field conditfons in and around Patiala (Punjab). Mating lasted for 3—6 hours. Mated females laid 35—50 eggs on an average within 2—3 days. Incubation period varied from 5—7 days with an average of 6.25 days and about 90% of the eggs hatched. The larval stage consisting of 5 instars was completed within 13—15 days. High moisture content accelerated development. The pupal stage lasted from 3—4 days with a pre-pupal period of 2 days. The total life cycle was completed in 23—28 days. The larvae and adults feed on the leaves so voraciously that only the veins are left while the entire soft tissue is consumed.

(Key words: Cassida enervis, Celosia argentea, pest, biology, life history)

INTRODUCTION

C enervis Boh. was found on *Alternanthera philoxeroides* (Mart) Griseb (Amaranthaceae) in and around Gauhati (SANKARAN & KRISHNASWAMY, 1974). But in Punjab *C. enervis* has been attacking *Celosia argentea* (Amaranthaceae)— an ornamental plant. The biology of *C. enervis* on *Celosia argentea* was studied in detail.

MATERIAL AND METHODS

The larvae of *Cassida enervis* were collected from the host plant *Celosia argentea* and were reared in the laboratory at a temperature of 28 ± 2°C and 70—80% R H. Freshly emerged adults were paired in collection jars (500 ml capacity) covered with muslin cloth and were fed on the fresh leaves of the host plant. Eggs laid on the leaves were counted daily, separately for each pair and the number of eggs hatched also was recorded. Newly hatched larvae were fed singly on the fresh leaves daily. The number of larval instars, total larval period and pupal periods were recorded. The data regarding the developmental stages and morphometric measurements, was put to statistical analysis. Various morphometric measurements were done with ocular micrometer and diagrams were drawn with the help of graph eye piece.

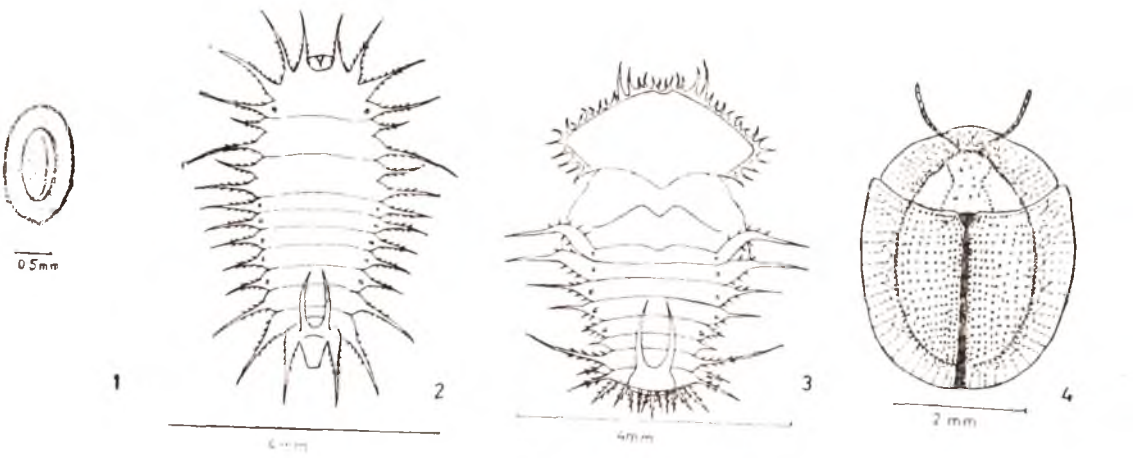
RESULTS

A. Life history of pest:

Complete account of different stages i. e., egg, larva, pupa and adult is as follows:

Egg (Fig. 1)

Eggs are laid singly on the ventral surface of leaf. Freshly laid eggs are creamy, in colour, elliptical in shape measuring on an average 1.06 ± 0.03 mm × 0.47 ± 0.08 mm (Fig. 1). A thin membranous sheath covers the egg with its margin sealed to leaf surface. The incubation period varied from 5–7 days with an average of 6.25 ± 0.05 days.



Figs. 1—4. *Cassida enervis* Boh; 1. Egg; 2. Fifth instar larva; 3. Pupa (dorsal view) 4. Adult.

According to SANKARAN & KRISHNASWAMY (1974) the incubation period ranged from 3–4 days.

First instar

During hatching the egg chorion is burst by the egg bursters and the head of the larva comes out first. The first instar larva measures 1.14 ± 0.02 mm × 0.55 ± 0.01 mm and is cream coloured. The first instar lasted from 3–4 days with an average of 3.5 ± 0.3 days.

Second instar

Second instar larva measures 1.93 ± 0.09 mm × 1.11 ± 0.3 mm. General colour and morphological characters in second instar larva are similar to those in first except measurements varies. The instar lasts for 2–3 days with an average of 2.5 ± 0.4 days.

Third instar

This instar resembles 2nd instar except that it is larger in size, measures 2.33 ± 0.1 mm × 1.31 ± 0.02 mm and turns greenish. The duration of this larval instar is 3 days.

Fourth instar

It also resembles 3rd instar, measures 3.39 ± 0.02 × 1 92 ± 0.02 mm. The duration of of fourth instar is 3 days.

Fifth instar (Fig. 2)

This instar is greenish in colour and measures 4.63 ± 0.05 mm × 2.3 ± 0.04 mm. Its duration is 2 days.

The fifth instar larva when fully grown stops feeding attaches to the leaf surface with its thoracic legs for pupation. In all the larval instars, there are present three pairs of thoracic legs, whereas, the abdominal legs are wanting. The larvae possess 16 pairs of hyaline lateral projections, two supra–anal processes which are moderately chitinized. Faecal matter and moulted skin of each instar is found attached to supra-anal processes.

Pre-pupa

Pre-pupa is greenish in colour. It attaches itself to the ventral surface of leaf. The pre-pupa almost remains inactive and motionless but if disturbed

it becomes active, moves for a short distance and again attaches itself to the leaf. Prepupal period lasts for 2 days.

Pupa (Fig. 3)

Pupa measures 4.74 ± 0.03 mm × 3.02 ± 0.1 mm. It is greenish with a pronotum shield developed in head and thoracic region. Rudiments of wings, antennae and appendages are well-developed. This stage lasts for 3–4 days with an average of 3.6 ± 0.5 days.

Adults (Fig. 4)

The mean length of freshly emerged beetle is 4.38 ± 0.2 mm and mean width is 3.54 ± 0.09 mm. Newly emerged adults are soft bodied, semi-transparent and greenish in colour. The body of the adult becomes hard after a span of 8 to 9 days and colour of the insect changes to golden green. Males are smaller than female.

B. Behaviour

1. Feeding behaviour

The newly hatched larva wanders a short distance from ootheca, punctures the leaf tissue and feeds particularly on the lower epidermis and palisade tissue, resulting in the formation of a small hole. In the proceeding larval stages i. e., second and third, the hole gets enlarged though feeding is quite slow. However, fourth instar larva is a voracious feeder, feeding along the periphery of hole which results in its further increase. Larst larval stage i. e., fifth instar feeds actively on both sides of the leaf. The feeding activity is somewhat slowed down on second day before it gets transformed into prepupal pupa which does not feed at all.

The newly hatched adults feed on fresh leaves for about eight days and attain full vigour before pairing occurs.

2. Mating behaviour

As mentioned above the males are smaller than the females. Mating lasts for 3–6 hours. It has also been witnessed that copulation occurs frequently with the same or different individuals.

3. Oviposition

Oviposition occurs 4 days after copulation and as early as 12 days after emergence of the female. The mated female lay 35–50 eggs on an average in 3–4 days.

DISCUSSION

Both the adults and larvae of *Cassida enervis* have been occassionally found to feed on *Ipomoea argentea* (F. Convolvulaceae) at Gauhati by SANKARAN & RAO (1972). GHANI (1971), and BALOCH (1977), however, studied the pest infesting *Convolvus arvensis* (Family Convolvulaceae) in various areas of Pakistan. Latter has found that the pest remains active in field from March to May and again from September to October. During the unfavourable seasons of the year i. e., excessive cold months viz. January, February and hot months viz., June, August, the pest remains inactive in adult stage. SANKARAN & KRISNASWAMY (1974) while studying the biology, morphology of immature stages and feeding of two *Cassida* species viz., *C.* sp. *enervis* and *C. syrtica* on *Alternanthera philoxeroides* (Family Amaranthaceae), they have also mentioned that the adult larvae of former species also feed on *A. sessilis* in Gauhati area. ZWOLFER & EICHHORN (1966) made significant observations on the host-range of certain species referrable to

genus *Cassida* where they have mentioned that these species attack various economic plants of family Cynareae. Economically important plants of the family Amaranthaceae and Chenopodiaceae have also been represented to be infested by several species of *Cassida* by KIMOTO (1966). In the present investigation the pest under reference not only breeds on an ornamental plant *Celosia argentea* but also attack plants of economic importance of families mentioned above (Amaranthaceae and Chenopodiaceae).

The pest under reference completes its life history on *Celosia argentea* within 23-28 days. However, on *C. arvensis*, the life-history is completed within 22–25 days (BALOCH, 1977) on *Alternanthera philoxeroides* in 19–23 days (SANKARAN & KRISHNASWAMY, 1974)

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REACTION OF FOUR PARASITOIDS TO SOME SYNTHETIC PYRETHROIDS

M. MANI, SUDHA NAGARKATTI & K. P. JAYANTH

Biological Control Laboratory, Division of Entomology & Nematology, Indian Institute of Horticultural Research, Bangalore, India 560 089

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Emulsifiable concentrate (EC) formulations of four synthetic pyrethroids namely decamethrin, permethrin, fenvalerate and cypermethrin were tested against four parasitoids *Apanteles angaleti* Muesebeck, *Bracon kirkpatricki* (Wilkinson), *Chelonus blackburni* Cameron (Hymenoptera, Braconidae) and *Eucelatoria bryani* Sabrosky (Diptera, Tachinidae). Adults were exposed to filter paper impregnated with pyrethroid solution for six hours and then transferred to untreated vials for observation. Synthetic pyrethroids proved non-toxic less toxic to the hymenopteran parasitoids tested but the tachinid showed differential response to different pyrethroids. Cypermethrin (Cymbush and Volrhocypermethrin) showed low toxicity (6.7 to 10.0% mortality) whereas permethrin exhibited high toxicity (93.3 to 96.7% mortality) to *E. bryani*.

(Key words: Apanteles angaleti, Bracon Kirkpatricki, Chelonus blackburni, Eucelatoria bryani)

INTRODUCTION

There has been increasing interest in the use of synthetic pyrethroids for the control of several crop pests, particularly in view of their quick action, persistence, low mammalian toxicity and high insecticidal efficiency. Some of the synthetic pyrethroids have been reported to substantially reduce pest incidence and increase the yield in crops such as cotton (LHOSTE & PIEDALLU, 1977; ROTE *et al.*, 1980). At the same time, some of the pyrethroids appear to be less toxic than some conventional insecticides to several parasitoids (ELSEY & CHETHAM, 1976; WESLEY & RADDLIFFE 1976; PLAPP & VINSON, 1977). In view of the possibility of increased use of synthetic pyrethroids in future to protect cotton from its major pests in India, it is desirable to know their effect on beneficial arthropod populations in cotton. The present study was conducted to determine the contact toxicity of EC formulations of four synthetic pyrethroids namely decamethrin, permethrin, fenvalerate and cypermethrin to the adults of *Apanteles angaleti* Muesebeck, *Bracon kirkpatricki* (Wilkinson), *Chelonus blackburni* Cameron and *Eucelatoria bryani* Sabrosky, four parasitoids of cotton bollworms. Of these, the first one is a major indigenous parasitoid of the pink bollworm, *Pectinophora gossypiella* (Saund) in India, *B. kirkpatricki* and *C. blackburni* are exotic species and attack pink and spotted bollworms while *E. bryani* is also an exotic parasite which attacks *Heliothis armigera* (Hubn.). All the three exotic parasites have

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demostrated their ability to parasitise cotton bollworms under Indian conditions and it appears likely they will become important components of the natural enemy complex of bollworms in this country.

MATERIAL AND METHODS

This study was conducted in the laboratory with one day old adults of the four parasitoids *A. angaleti, B. kirkpatricki, C. blackburni* and *E. bryani*. They were reared in the laboratory as suggested by NARAYANAN *et al.* (1956), BRYAN *et al.* (1969) and SANKARAN & NAGARAJA (1979).

A total of nine EC formulations of four synthetic pyrethroids, namely, decamethrin, permethrin, fenvalerate and cypermethrin were tested at recommended concentrations (Table 1). The commercial formulations of the above pyrethroids were diluted with water to get the desired concentration. A 15 × 3 cm filter paper strip was soaked in the pyrethroid solution, air dried for 2 hours and held in a glass vial (20 × 4 cm). Test insects were introduced into the vial and fed with 50% honey solution. The parasitoids were exposed to the treated filter paper for a period of 6 hours and later transferred to clean vials for further observations as described by GAITONDE (1978). Untreated control were also maintained using filter paper dipped in water and air dried before exposure to the parasitoids. Quinalphos was included as a standard chemical check.

Each treatment was repeated three times and each replicate comprised 10 adult parasitoids (1 ♀ : 1 ♂). Observations on the mortality of the parasitoids were recorded at the end of a 6 h exposure period, and 24 and 48 h of post-treatment period.

Mortality in the treatment was corrected using Abbot's formula. Zero values in the percentage mortality of adult parasites were converted into 0.01 and the data was then transformed into corresponding angles (arc-sine $\sqrt{\text{percentage}}$) for statistical analysis. Differences in the mortality of the parasites due to different pyrethroid EC formulations were analysed using 'F' test.

OBSERVATIONS AND DISCUSSION

The adults of *A. angaleti* were not affected by Ambush, Sumicidin and

TABLE 1. Details of the synthetic pyrethroids used in the present tests.

Common name	Trade name	Source	Formulation	Dose (ml/litre)	Concentration (%)
Decamethrin	Decis	Hoechst	1.8 EC	0.4	.0014
Permethrin	Volrhopermethrin	Voltas	20 EC	0.5	.0010
	Ambush	ICI	50 EC	0.2	.0010
Fenvalerate	Sumicidin	Rallis	20 EC	0.5	.0100
	Fenval	Searle	20 EC	0.5	.0100
Cypermethrin	Cymbush	ICI	25 EC	0.2	.0050
	Ripcord	NOCIL	10 EC	0.5	.0050
	Volrhocyper.nethrin	Voltas	25 EC	0.2	.0050
	BASF Cypermethrin	BASF	10 EC	0.5	.0050
Quinalphos (standard chemical) check	Ekalux	Sandoz	25 EC	2.0	.0500

TABLE 2. Effect of synthetic pyrethroids on the four parasitoids (figures in parenthesis are transformed values).

Name of the pyrethroid	*A. angaleti*			*B. Kirkpatricki*			*C. blackburni*			*E. bryani*		
	**6 h	*24 h	*48 h	**6 h	*24 h	*48 h	**6 h	*24 h	*48 h	**6 h	*24 h	*48 h
Decin	6.7 (12.9)	0.0 (0.6)	0.0 (0.6)	100.0 (90.0)	0.0 (0.6)	0.0 (0.6)	6.7 (9.4)	6.7 (12.8)	6.7 (12.9)	90.0 (80.0)	63.3 (53.3)	53.3 (47.5)
Volhropermethrin	43.3 (42.4)	0.0 (0.6)	0.0 (0.6)	30.0 (33.8)	0.0 (0.6)	0.0 (0.6)	3.3 (6.7)	0.0 (0.6)	6.7 (9.4)	100.0 (90.0)	96.7 (88.6)	96.7 (88.6)
Ambush	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	43.3 (42.4)	0.0 (0.6)	0.0 (0.6)	13.3 (17.8)	0.0 (0.6)	3.3 (6.7)	100.0 (90.0)	93.3 (87.2)	93.3 (87.2)
Sumicidin	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	100.0 (90.0)	10.0 (15.5)	6.7 (12.9)	6.7 (9.1)	0.0 (0.6)	3.3 (6.7)	100.0 (90.0)	26.7 (31.5)	30.0 (33.7)
Fenval	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	100.0 (90.0)	6.7 (12.9)	10.0 (15.5)	10.0 (15.5)	6.7 (9.4)	6.7 (9.4)	100.0 (90.0)	30.0 (33.7)	33.3 (36.1)
Cymbush	70.0 (57.6)	3.3 (6.7)	3.3 (6.7)	88.0 (69.1)	10.0 (15.5)	3.3 (6.7)	0.0 (0.6)	0.0 (0.6)	0.0 (0.6)	88.0 (69.1)	28.0 (26.6)	10.0 (12.2)
Ripcord	93.3 (81.3)	23.3 (29.3)	20.0 (26.6)	100.0 (90.0)	10.0 (15.5)	10.0 (15.5)	10.0 (15.5)	10.0 (15.5)	0.0 (0.6)	88.0 (69.1)	26.7 (31.5)	23.3 (29.3)
Volrhocypermethrin	16.7 (20.4)	26.7 (20.4)	13.3 (18.24)	36.7 (38.4)	16.7 (28.4)	10.0 (15.5)	6.7 (9.4)	3.3 (6.7)	3.3 (6.7)	76.7 (61.8)	13.3 (21.7)	6.7 (12.9)
BASF Cypermethrin	30.0 (33.8)	3.3 (6.7)	6.7 (9.4)	90.0 (80.0)	10.0 (11.2)	0.0 (0.6)	6.7 (9.4)	6.7 (9.4)	10.0 (15.5)	90.0 (80.0)	30.0 (33.8)	23.3 (29.3)
Quinalphos (check)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)

Comparison of significant effects	Level of significance	CD ($P = 0.05$)	Level of significance	CD ($P = 0.05$)	Level of significance	CD ($P = 0.05$)	Level of significance	CD ($P = 0.05$)
Between treatments	0.01	7.45	0.01	8.89	0.01	9.25	0.01	6.40
Between periods	0.01	4.08	0.01	4.87	NS	—	0.01	3.50
Interaction between treatment & period	0.01	12.90	0.01	15.39	NS	—	0.01	11.08

** Treatment period * Post-treatment period NS = Not significant.

Fenval at the end of the six hour exposure. But the other pyrethroids caused temporary knock-down of the insects (6.7 to 93.3%). However, most of the adults recovered during the post-treatment period. No mortality was observed with the formulations of permethrin, fenvalerate and decamethrin. Only cypermethrin formulations namely Cymbush, BASF cypermethrin, Volrho-cypermethrin and Ripcord inflicted 3.3, 6.7, 13.3 and 20.0% mortality of *A. angaleti*. With the standard chemical quinalphos, 100% mortality was observed in *A. angaleti* during the first hour of exposure.

During the six hours of exposure, varying numbers of adults of *B. kirkpatricki* became moribund in case of all he test pyrethroids. With Volrhoper-methrin, Ambush and Volrhocypermethrin, 30.0, 43.3 and 36.7% of adults become moribund respectively, while with the other pyrethroids more than 80% adults became moribund. At the end of the post treatment period, all the pyrethroids gave less than 10% mortality of the adults. Within one hour of exposure, 100% mortality of *B. kirkpatricki* was observed in quinalphos.

The response of *C. blackburni* did not vary significantly with different pyre-throids. The adults were tolerant to all the EC formulations of four pyrethroids. Less than 10% mortality was observed in all the treatments even 48 hours after exposure. Quinalphos inflicted 100% mortality within one hour of exposure.

All the synthetic pyrethroids caused temporary knock-down of the adults of *E. bryani*, but the tachinids started reviving during the post treatment period. Among the four pyrethroids, formulations of cypermethrin showed low toxicity of *E. bryani*. A mortality of 6.7, 10.0, 23.3 and 23.3% was observed with Volrhocypermethrin, Cymbush, Ripcord and BASF cypermethrin respectively. Sumicidin and Fenval inflicted 30.0 and 33.3% mortality of *E. bryani* Decis was moderately toxic resulting in 53.3% mortality. Both the formulations of permethrin gave more than 90% mortality of adults. The standard chemical caused 100% mortality of *E. bryani* during the first hour of exposure.

All the synthetic pyrethroids had little or no effect on the three hyme-nopteran parasites, *A. angaleti*, *B. kirk-patricki* and *C. blackburni*. Among them, *C. blackburni* was relatively more tolerant to the pyrethroid tested. Although *A. angaleti* and *B. kirkpatricki* became moribund in some treatments during the exposure period, they revived during the post-treatment period. The low toxicity of synthetic pyrethroids to some other hymenopteran parasitis was reported by WADDIL (1978) and WILKINSON *et al.* 1979). Temporary knockdown effects was more pronounced in case of *E. bryani* when they were exposed to the synthetic pyrethroids. Pyrethroids are known for knock-down or temporary knock-down effects on insects (ANONYMOUS, 1980). Percentage of revival in *E. bryani* revealed that cypermethrin (Cymbush and Volrhocypermethrin) and fenvalerate were relatively less toxic to this tachinid.

The present study indicated that there was no difference in toxicity among the synthetic pyrethroids to the three hymenopteran parasites tested but pronounced differences were observed in their toxicity to *E. bryani*. These pyrethroids should therefore be subjected

to further testing against other important indigenous natural enemies of major cotton pests before recommending them for use in integrated pest management in cotton.

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DEVELOPMENT OF AN ARTIFICIAL DIET FOR REARING THE SPOTTED BOLLWORM *EARIAS VITTELLA* (NOCTUIDAE : LEPIDOPTERA)

CLEMENT PETER & SUDHA NAGARKATTI

Division of Entomology, Indian Institute of Horticultural Research, Hesserghatta Post, Bangalore, India 560 089

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The present investigation describes the development of an artificial diet for successfully rearing the spotted bollworm, *Earias vittella*. The three main base ingredients used in this diet were soaked beans, okra leaf powder and cotton seed oil cake powder. The performance of the artificial diet compares favourably with that of the natural diet for rearing this insect.

(Key words: Earias vittella, artificial diet)

INTRODUCTION

The spotted bollworm *Earias vittella* F. is a serious pest of cotton and okra in India (SOHI, 1964) and causes serious crop losses every year. To examine the possibilities of biological control of this pest it is imperative that a large number of the host insect is available for rearing its parasites. The rapid supply of this insect in large numbers for this purpose is impractical when larvae were bred on malvaceous plants. An artificial diet developed by PANT & ANAND (1972) for rearing *Earias vittella* was not adequate for this particular requirement. Hence, the present work describes the development of an artificial diet on which *E. vittella* colonies could be raised successfully.

MATERIALS AND METHODS

The artificial diet of SHOREY & HALL (1965) was taken as the basis for formulating the ingredients required for rearing *Earias vittella*. In all, eight different diets were tested with slight modifications until the most appropriate was obtained. The ingredients used for this artificial diet were as follows: soaked beans *(Phaseolus vulgaris)* 100 g; okra leaf powder 20 g; cotton seed oil cake 3 g; yeast 5.2 g; methyl parahydroxy henzoate 1.2 g; sorbic acid 1 g; streptomycin 0.4 g; agar agar 5.2 g; multivitaplex 2 capsules; water 500 ml. Method of preparation: 200 ml of distilled water was added to the okra leaf powder and heated until it boiled. It was then cooled to room temperature. The seed coat of the beans soaked overnight was slipped off and 100 g of it was crushed in a blender with 100 ml water. The leaf powder with water is added to this along with the cotton seed oil cake, yeast and methyl parahydroxy benzoate and blended again. The agar is dissolved in 200 ml of hot water, boiled, cooled to about 60°C and is added to the other ingredients in the blender. The remaining ingredients, viz., sorbic acid, ascorbic acid and multivitaplex are added last and the whole mixture is blended thoroughly for about 1 minute. While it is still warm, it is poured into sterilized glass vials (3" × 1") to half its volume and is allowed to cool.

When the diet in the vial solidified, pin holes were made on its surface with a sterilized needle. Two freshly hatched larvae were

transferred into each vial, plugged with sterilized cotton, and the tray containing these vials was placed in a dark chamber to prevent the movement of the larvae to the cotton plug. When the larvae are fully developed they either pupated on the cotton plug or on the diet surface. These were collected and placed in a jar until the moths emerged.

This method of diet preparation was followed for rearing fifteen generations of *Earias* continuously in the laboratory. During the third generation, the quality of the artificial diet for rearing this insect was compared with that of the natural diet (okra fruit).

RESULTS AND DISCUSSION

The performance of the artificial diet for rearing fifteen generations of *E. vittella* is presented in Table 1. While there was a wide fluctuation in the survival percentage between the first and the second generation, it showed a steady trend in the subsequent generations. The moths which emerged from the larvae that developed on this diet were quite normal and healthy until the last two generations when the size of the adults were smaller than normal and a few deformed moths too appeared.

TABLE 1. Percentage survival of *E. vittella* reared on artificial diet.

Generation	Total development period (in days)	Mean	% survival
1	38—45	39.7	26.0
2	35—55	36.9	67.8
3	31—41	35.0	61.1
4	27—41	28.3	60.0
5	25—37	28.5	60.9
6	23—44	25.6	70.2
7	26—44	29.0	56.0
8	25—36	28.7	68.7
9	26—37	28.0	86.8
10	23—31	25.5	75.4
11	22—34	26.4	68.3
12	24—33	25.4	75.0
13	22—30	23.5	93.4
14	21—27	24.0	74.5
15	22—30	24.5	56.2

An evalution of the quality of the artificial diet as compared to the natural diet for rearing *E. vittella* was made on the basis of its biology as studied on both these diets. The results of this investigation is presented in Table 2.

TABLE 2. Biology of *E. vittella* on natural diet and artificial diet.

Parameter	Natural diet	Artificial diet
Incubation period	3—6 days (3.2)	3—5 days (3.6)
Larval period	9—14 days (12.5)	17—22 days (20.5)
Pupal period	6—11 days (8.0)	8—15 days (9.6)
Total development period	18—31 days (24.1)	31—41 days (31.0)
Fecundity	68—248 eggs (125.4)	28—123 eggs (76.4)
Adult longevity	3—6 days (5.3)	4—7 days (4.5)
Sex-ratio (M:F)	1 : 1.50	1 : 1.11
Survival percentage	85.0	60.0

The figures in parenthesis are mean values.

It was seen that in some aspects the artificial diet compared favourably with the natural diet. There was very little difference between the two diets with respect to the fecundity, incubation period, sex ratio and adult longevity. A slight difference in the larval period and total development period between the two diets was recorded.

The present investigation revealed that *E. vittella* could be successfully reared in large numbers on this diet throughout the year. The ingredients used for this diet too were few, easily available and economical. It could be successfully utilised for rearing large numbers of *Earias* larvae either for biological control programme or screening varieties in host-plant resistance studies.

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AN ARTIFICIAL DIET FOR REARING OF *SPILOSOMA OBLIQUA* WALK. (ARCTIIDAE : LEPIDOPTERA)

K. NARAYANAN

Division of Entomology/Nematology, Indian Institute of Horticultural Research
Hessaraghatta Lake Post, Bangalore, India 560 089

(Received 14 July 1984)

An artificial diet has been developed for laboratory rearing of *Spilosoma obliqua*. Different parameters like larval and pupal development period, pupation, adult recovery, fecundity and sex ratio have been studied. The results indicated that *S. obliqua* can be successfully mass-reared on the present artificial diet.

(Key words: artificial diet, *Spilosoma obliqua)*

INTRODUCTION

Spilosoma (Diacrisia) obliqua, commonly known as Bihar hairy caterpillar, is a very serious polyhagous pest, causing damage by way of defoliation to many of the crops. JACOB & THOMAS (1972) reported the occurrence of a nuclear polyhedrosis virus in *S. obliqua*. Recently NARAYANAN (1984) has shown the efficacy of microsporidian viz., *Nosema* sp. for the control of *S. obliqua* under laboratory conditions. A preliminary requirement for continuous and mass propagation of insect viruses and protozoan pathogens for large scale field trials, is the availability of the living host insects throughout the year, as these pathogens are obligate in nature, requiring living hosts for their multiplication. Rearing of insects on natural foliage, dependence upon the periodic presense of either insect and / or its natural food, decreases the chance of continuous production. Further, rearing on the natural hosts, is a labour intensive one and also limited by the development of intercurrent diseases which often eradicate the laboratory culture. These problems are minimised with the development of artificial diet, which will permit controlled, sustained rearing of host insects under sterile conditions and in turn mass production of insect pathogens. With this in view, it was decided to develop an artificial diet for rearing of *S. obliqua*.

MATERIALS AND METHODS

The various dietary ingredients were chosen (Table 1) depending on the important requirement of the diety components for the phytophagous insects (VANDERZANT, 1966) and the larval diet was prepared as follows. All the ingredients except agar were finely blended in a blender cum mixer with 200 ml of water. Agar was separately dissolved in 200 ml of boiled water, cooled (60–70°C) and then added to the mixer. Diet thus prepared was then dispensed into a clean glass vial of 7.5×2.5 cm. Five neonate larvae of *S. obliqua* were transferred into each of the vials and it was reared upto second instar for nearly six days. Later, they were reared individually till pupation. The experiment was conducted in a BOD

TABLE 1. Composition of different ingredients used for the preparation of artificial diet for *S. obliqua*.

Sl. No.	Ingredient	Quantity
1.	Cowpea flour	15.0g
2.	Castor leaf powder	5.0 g
3.	Casein	10.0 g
4.	Wheat germ	10.0 g
5.	Glucose	4.0 g
6.	Wesson salt mixture	4.0 g
7.	Ascorbic acid	1.5 g
8.	Yeast	5.0 g
9.	Sorbic acid	0.5 g
10.	Methyl parahydroxy benzoate	1.0 g
11.	Vitiolin	2 capsules
12.	Multivitaplex	1 tablet
13.	Formaldehyde 10%	1 ml
14.	Streptomycin sulphate	0.12 g
15.	Agar	8.0 g
16.	Water	400.0 ml

incubator maintained at 27±2°C. A comparison was also made between the larval and pupal duration, pupation, pupal weight, fecundity and sex ratio when the insects were reared on artificial diet and natural diet, viz., castor leaf.

RESULTS AND DISCUSSION

The results of the rearing of *S obliqua* on artificial diet are summarised in Table 2. It is evident from the result that the larvae reared on artificial diet showed more or less equal in larval and pupal duration, compared to those reared on natural food. The percentage pupation and adult recovery were found to be similar to those reared on castor leaves. Thus, it is evident that the artififcial diet with all the above mentioned essential ingredients, appears to be well suited for mass rearing of *S obliqua*.

Acknowledgements. The author is grateful to Mr. D. L. SHETTI for his help and to Dr. K. L. CHADHA, Director of the Institute for the facilities provided.

TABLE 2. Comparison of development of *S. obliqua* reared on natural diet and artificial diet.

		Natural diet	Artificial diet
1. Average larval period	(days)	29.65 (Range 27–33)	31.66 (Range 30–35)
2. Average pupal period	(days)	13.00 (Range 12–16)	14.15 (Range 13–17)
3. Pupation	(%)	95	95
4. Pupal weight	(mg)	653.61	543.80
5. Adult recovery	(%)	100	100
6. No. of eggs laid by ♀		(Range 658–856) 756	(Range 590–901) 684
7. Sex ratio	(♂ : ♀)	1 : 1	1.1 : 1

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INFLUENECE OF TEMPERATURE ON THE DEVELOPMENT OF *BREVIPALPUS OBOVATUS* (ACARINA : TENUIPALPIDAE)

MEENA GOYAL, G. L. SADANA & NEELAM K. SHARMA

Department of Zoology, Punjab Agricultural University, Ludhiana, India 141 004

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The rate of development of *Brevipalpus obovatus* was studied at temperatures 15, 20, 25 and 30 and 35, ±1°C on the leaf of goldenrod, *Solidago canadensis*. The rate of development was maximum at 30°C and minimum at 20°C. The temperatures 15°C and 35°C proved unsuitable for the development of all stages of the mite. Maximum mortality was observed at 20°C and minimum at 25°C and maximum fecundity at 25°C and minimum at 20°C. The temperature 25°C proved most suitable for the development of *B. obovatus* as oviposition period, fecundity and rate of hatching were more and mortality was less at this temperature.

(Key words: Brevipalpus obovatus, development, temperature)

INTRODUCTION

The false spider mite, *Brevipalpus obovatus* of the family Tenuipalpidae is distributed in many parts of the world and has been reported to infest many types of plants including vegetables, fruits, ornamental and medicinal plants (BAKER, 1949; GHAI, 1964; GUPTA, 1970; CHAUDHARI, 1972; WAHAB *et al.*, 1974; MEYER, 1979; SADANA *et al.*, 1981; 1982). Recent surveys have shown that it is established well on different types of plants at Ludhiana (SADANA, 1982). Therefore, an effort has been made to study its most preferred host, the goldenrod, *Solidago canadensis* L. at different levels of temperature.

MATERIALS AND METHODS

B. obovatus was collected from the fields in Punjab Agricultural University Campus, Ludhiana and reared on goldenrod, *S. canadensis* L. in the laboratory. Total absence of males in laboratory reared population showed that they reproduce by parthenogenesis.

The rate of development of *B. obovatus* was studied at different temperatures, i. e., 15, 20, 25, 30 and 35, ± 1°C in the laboratory. The newly emerged female mites were released on small pieces of leaf discs which were placed over moist cotton in petri dishess. At least ten such petri dishes were used for experiment at each temperature levels. Daily counts of eggs laid by the mites were recorded. The durations of various stages viz., egg, larva, protonymph and deutonymph were also noted. Data on preoviposition, oviposition, postoviposition periods, fecundity and longevity were obtained from the records of different experimental series maintained separately for each temperature.

RESULTS

Pre-oviposition, oviposition and post-oviposition periods

The data on pre-oviposition, oviposition- and post-ovigosition periods in Table 1 indicates that these periods occupied 6.90±0.54, 17.00±0.78 and 21.33±0.81 days at 20°C, 6.28±0.45, 9.69±0.46 and 8.73±1.05 at 25°C and 5.92±0.82, 3.85±0.68 and 6.90±0.90 days at 30°C, respectively. It was

TABLE 1. Pre-oviposition, oviposition, post-oviposition periods (in days), fecundity, daily rate of egg production and longevity (in days) of *B. obovatus* at different temperatures.

Temperature (± 1°C)	Pre-oviposition period Mean ± SD	Oviposition period Mean ± SD	Post-oviposition period Mean ± SD	Fecundity Mean ± SD	Daily rate of egg production*	Longevity Mean±SD
15	—	—	—	—	—	—
20	6.90 ± 0.54	17.00 ± 0.78	21.33 ± 0.81	3.92 ± 0.75	0.23	45.22 ± 0.79
25	6.28 ± 0.45	9.69 ± 0.46	8.73 ± 1.05	16.67 ± 0.47	1.72	24.09 ± 1.08
60	5.92 ± 0.82	3.85 ± 0.68	6.90 ± 0.90	10.15 ± 0.66	2.71	16.45 ± 0 99
35	—	—	—	—	—	—

* Fecundity divided by oviposition period (days).

evident that with increase in temperature the corresponding periods decreased in duration.

Duration of different stages

The data on duration of different stages in Table 2 reveals that the rate of development is greately infuenced by temperature. The rate of development increased with increase in temperature. It was maximum at 30°C and minimum at 20°C. Low and high temperatures, i.e., 15°C and 35°C, respectively were unsuitable for its development. The average duration of each stage decreased with the rise in temperature. The incubation period was minimum (7.25± 0.82 days) at 30°C and maximum (19.20 ±0.40 days) at 20°C. The duration of larval, protonymphal and deutonymphal stages was minimum at 30°C being 6.50±0.50, 4.34±0.62 and 4.25±0.43 days and maximum at 20°C being 11.71±0.43, 9.75±0.43 and 8.00±0.00 days, respectively. A similar trend was also observed in total developmental period. It was observed to be minimum at 30°C being 22.42±0.95 days and maximum at 20°C being 47.50±0.50 days.

Fecundity and longevity

The mean number of eggs laid by a female at 20, 25 and 30°C were 3.92 ±0.75, 16.67±0.47 and 10.15± 0.66, respectively (Table 1). The mites had a life span of 45.22±0.79, 24.09±1.08 and 16.45±0.99 days at 20, 25 and 30°C respectively (Table 1). The average survival period decreased with the increase of temperature. Thus, the temperature affects the fecundity and longevity of this mite to a great extent.

Rate of egg production

The daily rate of egg production was also affected considerably at different levels of temperatures. The number of eggs laid per female per day at 20, 25 and 30°C was 0.23, 1.72 and 2.71, respectively (Table 1). It is, therefore, evident that less number of eggs were produced at low temperature than at high temperature.

TABLE 2. Duration of different stages (in days) of *B. obovatus* at different temperatures.

Temperature (± 1°C)	Incubation period		Larval period		Protonymphal period		Deutonymphal period		Total period	
	Mean ± SD	DI*	Mean ± SD	DI	Mean ± SD	DI	Mean ± SD	DI	Mean ± SD	DI
15	Unsuitable for development									
20	19.20 ± 0.40	5.20	11.71 ± 0.43	8.53	9.75 ± 0.43	10.26	8.00 ± 0.0	12.50	47.50 ± 0.50	2.10
25	9.64 ± 0.48	10.38	7.15 ± 0.95	13.99	7.16 ± 0.99	13.97	6.83 ± 0.80	14.64	30.72 ± 0.86	3.26
30	7.25 ± 0.82	13.80	6.50 ± 0.50	15.39	4.33 ± 0.62	23.09	4.25 ± 0.43	23.52	22.42 ± 0.95	4.46
35	Unsuitable for development									

* DI — Developmental index is 100 divided by mean duration of each stage in days.

Viability of eggs and mortality

The percentage of hatching was maximum at 25°C being 92.98 and minimum at 20°C being 74.30. At 15 and 35°C, none of the eggs hatched (Table 3). The eggs kept at these temperatures maintained the shape and colour as that of freshly laid eggs for a month at 15°C but they shrivelled up and became opaque at 35°C within 2–3 days. Maximum mortality from egg to adult and from larvae to adult was observed at 20°C being 80.00 and 73.08 per cent and minimum at 25°C being 21.05 and 15.10 per cent, respectively (Table 3).

It is evident from the results that 25°C proved most suitable for the development of *B. obovatus* as oviposition period, fecundity and percentage of hatching was more and mortality less at this temperature.

DISCUSSION

The effect of different levels of temperature on the development of *B. obovatus* revealed that its rate of development was maximum at 30°C and minimum at 20°C. The total fecundity was maximum at 25°C. The reason for fecundity being maximum at 25°C rather than at 30°C is that the longevity at 25°C is more than at 30°C. The fecundity is not only dependent on the rate of egg production but also on the longevity. The mortality was maximum at 20°C and minimum at 25°C. Out of the different levels of temperatures tested, 25°C was found to be most suitable for its development. The oviposition ceased below 20°C and above 30°C. These observations are in agreement with those of MORISHITA (1954) on *B. inornatus* who studied its development on anthuriums leaves.

The rate of development of *B obovatus* is greatly influenced by temperature. A marked effect of temperature on the development of brevipalpid mites has also been observed by many workers. *B. phoenicis* completes its development in 48.9±1.5, 29.30±0.4 and 18.6±0.5 days at 20, 25 and 30°C, respectively (HARAMOTO, 1969), *B. californicus* in 26.2 days at temperatures ranging between 17.9 and 23.9°C (MANGLITZ & CORY, 1953). But the observations of LAL (1979) are in contrast to the present observations and

TABLE 3. Data on the development of *B. obovatus* showing viability of eggs and mortality at different temperatures.

Temperature (± 1°C)	No. of eggs examined	No. of eggs hatched	No. of adults developed	Percentage of hatching	Total mortality from egg to adult percentage	Total mortality from larva to adult in percentage
15	35	Nil	—	—	—	—
20	70	52	14	74.30	80.00	73.08
25	57	53	45	92.98	21.05	15.10
30	50	38	13	76.00	74.00	65.79
35	32	—	—	—	—	—

also to those of HARAMOTO (1969), MANGLITZ & CORY (1953) and MORISHITA (1954) who maintained that *B. phoenicis* completed its development in 20.02 days at an average temperature of 21.0°C and 29.66 days at 26.6°C on *Clerodendron siphonanthus*.

The development of *B. obovatus* was much faster at the temperatures above 25°C than below it. However, the mortality of immature stages increased with increase in temperature beyond 25°C and its development was no longer possible at temperature above 30°C and below 20°C. These findings are in accord with those of HARAMOTO (1969).

The pre-oviposition, oviposition and post-oviposition periods were longer at 20°C, than at 25°C or 30°C. These observations are in close agreement with those of MORISHITA (1954). The females lived longer at 20°C than at 25°C but they laid only one-fourth as many eggs at 20°C than at 25°C, as they remain quiescent for most of the time. MORISHITA (1954) reported 75 days as the maximum life of an adult female at 20°C but in the present studies the females survived only for 45.22±0.79 days at this temperature. The present observations are in agreement with those of HARAMOTO (1969) on *B phoenicis*.

The effect of low temperature on *B. obovatus* resulted in the prolongation of the pre- and post-oviposition and developmental periods but reduction in oviposition period so that a marked decline in the number of eggs laid by the mite was noted.

B. obovatus like *B. californicus* and *B. phoenicis* has the ability to reproduce freely within a wider range of temperature (20°C–30°C) but most efficiently 35°C.

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PRECOCENE - I INDUCED INHIBITION AND JH-III RESTORATION OF OVARIAN GROWTH IN THE RED COTTON BUG, *DYSDERCUS KOENIGII* (PYRRHOCORIDAE - HETEROPTERA)

J. V. RAMALAKSHMI, P. S. VIMALA DEVI, APARNA RAY & P. S. RAMAMURTY

School of Life Sciences, University of Hyderabad, Hyderabad, India 500 134

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The anti-juvenoid precocene-I was topically applied to newly emerged females in different dosages ranging from 50 to 250 μg per insect and its effects were studied by various parameters. At the dosage tried, precocene has negligible effect on mortality rate and is well tolerated. The body weight drops to almost one half with the highest dose. In normal and acetone treated control insects, the ovarian weight is 14mg/ insect, while it is low at 3.5 mg in 200 μg precocene treated insect. The protein content per insect ovary remains very low in 200 μg precocene treated insects whereas it is almost 13-15 times this value in the normal and acetone treated controls. This is again dose-dependent, showing the highest inhibition with 200 μg dosage. All these JH deficiency effects on egg-maturation are partially reversible with exogenons JH-III application at different dosages and at diiferent time intervals.

(Key words: precocene-I, inhibition, ovarian growth, JH-III, *Dysdercus koenigii)*

INTRODUCTION

Todate, several studies exist on the hormonal control of ovarian development in different groups of insects. In Heteroptera, the existing reports show that allatectomy either completely inhibits egg maturation (FRIEDEL, 1974; JALAJA & PRABHU, 1977; TIWARI & SHRIVASTAVA, 1979) or merely diminishes egg production (DAVEY, 1967; PATCHIN & DAVEY, 1968; PRATT & DAVEY, 1972). BOWERS *et al.* (1956) have isolated two chromene derivatives from the common bedding plant *Ageratum houstonianum*, Precocene-I and Precocene-II. In adult insects, precocene induces destruction of the corpus allatum that results in the deficiency of JH (gonadotropic hormone) which, in turn, causes cessation of vitellogenesis and other successive reproductive processes (BOWERS, 1976, BOWERS *et al.*, 1976; MASNER *et al.*, 1979). Recent studies have demonstrated that the corpora allata are selectively destroyed by accumulation of metabolites of precocene formed *in situ* (BROOKS *et al.*, 1979; MULLER *et al.*, 1979; PRATT *et al.*, 1980; PRATT *et al.*, 1982).

This work describes the effect of various dosages of precocene-I on mortality rate, oocyte maturation by protein yolk deposition and egg-laying in the red cotton bug, *Dysdercus koenigii*. Effects of JH-III recovery are also described,

MATERIALS AND METHODS

Stock colony of the red cotton bugs *Dysdercus koenigii* was reared in the laboratory at 26 ± 1°C, 70 ± 5% RH and 14:10 L D

period in a BOD incubator on soaked cotton seeds.

Newly emerged adult females (within 10 to 20 min) were treated topically with various dosages of precocene-I ranging from 50 to 250 μg (Ega-Chemie, W. Germany) dissolved in 10 μl acetone. Equal number of males of the same age group were kept together with the experimental insects in glass containers. Control insects were administered 10 μl acetone. Untreated insects were also kept along with the experimental and acetone treated controls. All the insects were weighed and sacrificed on 6th day (5 days old).

JH-III was applied topically to the 200 μg precocene-treated insects in various dosages ranging from 5 μg to 15 μg on different days after treatment. The insects were weighed and sacrified on the 8th day (7 days old). After sacrifice, various parameters were checked. The ovaries were dissected out in cold insect Ringer solution. The length and width of the terminal oocytes were measured, using ocular micrometer. For weighing a single pan mettler balance was used. The wet weight of the ovary was determined after quickly blotting dry with a blotting paper. Protein estimation was carried out by the method of LOWRY *et al.* (1951) after trichloroacetic acid precipitation. Bovine serum albumin (Fraction V) was used as standard.

RESULTS

All dosages of precocene are well tolerated and the mortality rate remains low between 5 and 20%. Various parameters checked in the present study show a dose dependent response (Table 1),

The lower values of body weight in precocene treated insects are proportional to the increase in precocene dosages. The maximum inhibition of body weight increase occurs in the case of 200 μg precocene treated insects. It remains more or less the same, also in 250 μg treated insects. This is about 50% of the control values (Table 1).

The length, width and volume of the terminal oocyte of precocene treated insects are comparatively lower than in controls. The drop in values as shown in Table 1 is 2.5 times, in the case of 250 μg precocene treated insects when compared to normal insects.

The ovarian weight becomes 1/6th in 250 μg precocene treated insects, as compared to that of the controls (Table 1). The ovarian protein decreases drastically from 1803 μg to 505 μg per insect in 50 μg precocene, treated insects. With increasing dosage up to 150 μg of precocene, a further reduction in protein content is seen and this remains more or less the same with still higher dosages. The ovarian protein, when expressed per mg tissue, also decreases in precocene treated insects and the protein content drops to 50% of the control values.

Table 2 shows the effect of partial inhibition of egg maturation. Control insects usually lay eggs on 8th day and the number of eggs varies between 100 and 120. On the other hand the 50 μg precocene treated insects lay the eggs rather late between 19th and 21st day but the number of eggs laid remains more or less the same.

The insects were topically administered various doses of JH-III, ranging from 5 to 15 μg either on the 3rd or 4th day of post-precocene treatment. The response to various doses of JH is linear, as reflected in the increase in the weight of the ovary as well as its protein content. (Table 3)

As shown in Table 3, when 15 μg JH applied on 3rd day after precocene treatment, there is a 5 fold increase in the ovarian weight and 8 fold increase in total ovarian protein, in

TABLE 1. Effect of precocene-I on the ovaries in *Dysdercus koenigii*.

Treatments	% Mortality	Insect body wt (mg)	Ovarian wt (mg)	Oocyte length (mm)	Oocyte width (mm)	Oocyte Volume (mm)	Protein μ(g)/ insect ovary	Protein μ(g)/ mg ovary
Normal (7)	0.016 ± 0.002	106 ± 9.8	14.4 ± 2.5	0.606 ± 0.02	0.545 ± 0.039	0.11 ± 0.028	2207 ± 381	106 ± 10.7
Acetone treated control (8)	11.3 ± 6.0	102 ± 6.02	14.1 ± 1.5	0.62 ± 0.04	0.612 ± 0.03	0.126 ± 0.015	1803 ± 231	111.6 ± 11.9
Precocene 50 μg (6)	11.3 ± 4.0	97.3 ± 10.6	5.5 ± 0.68	0.436 ± 0.047	0.433 ± 0.047	0.0395 ± 0.0028	505 ± 92	78.2 ± 8.6
100 μg (7)	22.6 ± 5.7	81.3 ± 8.9	5.05 ± 0.49	0.331 ± 0.047	0.29 ± 0.043	0.0175 ± 0.0067	230 ± 41	59 ± 3.9
150 μg (6)	15.2 ± 6.2	79.8 ± 4.9	4.12 ± 0.61	0.27 ± 0.033	0.287 ± 0.06	0.0081 ± 0.0033	183 ± 46	57.6 ± 12.8
200 μg (8)	7.0 ± 3.0	68.1 ± 4.4	3.53 ± 0.51	0.266 ± 0.027	0.234 ± 0.022	0.0068 ± 0.0014	139 ± 5	52.5 ± 10.6
250 μg (5)	26.0 ± 7.1	62 ± 3.7	2.38 ± 0.19	0.245 ± 0.011	0.22 ± 0.008	0.0063 ± 0.0006	150 ± 13	50.0 ± 11.0

The value represents the mean ± S D for the number of observations on animals given in parentheses.

TABLE 2. Effect of Precocene-I on oviposition in *Dysdercus koenigii*.

Treatment	No. of insects treated	No. of insects survived	No. of days required for egg laying	No. of eggs laid
Control (Acetone treated)	50	45	7— 8	110 ± 10
50 µg precocene	40	32	19—21	90 ± 10

TABLE 3. Effect of JH-III on precocene treated adult females of *D. koenigii*.

Treatments	Ovary wt. (mg)/ insect	Protein (µg)/insect ovary	Protein (µg)/ mg ovary
Acetone treated (4)	60.7 ± 4.5	4527 ± 385	121 ± 22
Precocene treated (10)	2.21 ± 0.33	188 ± 19	57 ± 7
5 µg JH on 3rd day of precocene treatment (6)	6.30 ± 1.04	704 ± 223	105 ± 12
10 µg JH on 3rd day of precocene treatment (7)	8.86 ± 1.68	1180 ± 355	110 ± 11
15 µg JH on 3rd day of precocene treatment (5)	11.60 ± 1.37	1654 ± 211	123 ± 20
5 µg JH on 4th day of precocene treatment (8)	10.30 ± 2.70	1006 ± 125	113 ± 12
10 µg JH on 4th day of precocene treatment (5)	12.60 ± 3.10	1520 ± 348	107 ± 9
15 µg JH on 4th day of precocene treatment (8)	14.26 ± 2.02	1831 ± 345	117 ± 10
5 µg JH on 3rd day and 5 µg JH on 4th day of precocene treatment (3)	7.13 ± 0.07	902 ± 98	104 ± 13
10 µg JH on 3rd day and 10 µg JH on 4th day of precocene treatment (3)	10.02 ± 0.90	1326 ± 117	118 ± 11

The values represent mean ± SD of the number of determinations given in parentheses.

comparison to that of precocene treated controls. When JH-III (15 µg) is applied on 4th day after precocene treatment, a 7-fold increase in ovarian weight and a 9-fold increase in total ovarian protein are seen (Table 3) and these are slightly higher than the values mentioned earlier.

The ovarian protein, expressed per mg tissue shows an increase in JH-treated insects on either the 3rd day or the 4th day and that is about 2 times greater than precocene treated control values.

Table 4 shows the number of oocytes which undergo maturation during the

TABLE 4. Effect of JH-III on Oocyte maturation in precocene treated insects.

Treatments	No. of insects treated	No. of oocytes/ ovariole in the process of maturation on 8th day
Control	40	9—11
200 µg Precocene-I treatment followed by JH-III (15 µg) on 4th day	20	3—4

first reproductive cycle on 8th day. In control insects 9 to 11 oocytes per ovariole show active yolk deposition. On the other hand, this number is fairly low and is about 1/3rd in case of 15 µg JH-recovered (4th day) insects.

DISCUSSION

Our results show a reduction in size of the terminal oocyte and total protein content of the ovary in precocene treated females. In Heteroptera, since ovarian maturation and protein yolk deposition are under the influence of JH (KELLY & DAVENPORT, 1976; RANKIN & RIDDIFORD, 1978; DAVEY, 1981) it seems reasonable to suggest that the anti-juvenoid, precocene depresses haemolymph JH titres in *Dysdercus koenigii* adults, as it appears to be the case in other insects.

In *D. koenigii* precocene-I inhibits the egg maturation in a dose dependent manner (WILSON *et al.*, 1983). A single topical application of 50 µg causes only partial inhibition of vitellogenesis. The time required for egg laying is much longer in precocene treated insects in comparison to acetone-treated insects and it ranges between 19 and 21 days. This is presumably due to the low vitellogenic activity, caused by partial inhibition of JH output by CA. On the other hand 200 µg precocene treatment results in total inhibition of vitellogenesis because even if the insects are left for 30 to 40 days, they do not show any sign of vitellogenesis.

Precocene treatment ultimately causes chemical destruction of CA and this effect is irreversible in some insects. The effect is possibly due to a reactive precocene metabolite, produced by CA cells (UNNITHAN *et al.*, 1977; BROOKS *et al.*, 1979: MULLER, 1979; FEYEREISEN *et al.*, 1981). The CA from adult female of *Locusta migratoria* rapidly metabolises Precocene-I to dihydrodiols in the presence of high level of epoxidases which causes selective cell death in CA (PRATT *et al*, 1980; 1982).

The effect of precocene is spontaneously reversible with time, in *Drosophila melanogaster* (LANDERS & HAPP, 1980; WILSON *et al.*, 1983), and in Aphids like *Acrythosiphon* (MACKAUER *et al.*, 1979) and in *Myzus* (HALE & MITTLER, 1981). In contrast to its effects on *Glossina morsitans* (SAMARANAYAKA RAMASWAMY & CHOUDARY. 1982), here precocene does not induce sterility in F_1-generation, when applied in 50 µg dose to *D. koenigii* adults. F_1-generation adults show normal fertility and lay more or less the same number of eggs.

Exogenous JH-III application on precocene treated insects counteracts the deleterious effect of this substance up to some extent and restores the protein content of the ovaries to a certain degree (BOWERS *et al.*, 1976; BOWERS & MARTINEZ-PARDO, 1977; LANDERS & HAPP, 1980; NICHOLAS *et al.*, 1982). In *Dysdercus koenigii*, 3-4 eggs

usually show vitellogenesis on the 8th day and a partial recovery of egg maturation is achieved.

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FURTHER RECORDS OF TWO MORE DROSOPHILID SPECIES (DIPTERA : DROSOPHILIDAE) FROM KASHMIR, INDIA

A. KUMAR & J. P. GUPTA

Genetics Laboratory, Department of Zoology, Banaras Hindu University, Varanasi, India 221 005

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Altogether seventeen species representing two genera of Drosophilidae are collected from Kashmir valley, India. Among them, *D. kashmirensis* belonging to the *polychaeta* species group of the genus *Drosophila* is discovered as a new species, whereas *Scaptomyza himalayana* Takada is recorded for the first time from India. A key to the species of the *polychaeta* species group is provided. The metaphase chromosomes of *D. kashmirensis* consist of 2 unequal pairs of rods, 1 pair of metacentric and 3 unequal pairs of submetacentric chromosomes.

(Key words: Drosophila, new species, key, Kashmir)

During recent years there have been numerous efforts to explore the Indian fauna of Drosophilidae. As a result, several ecologically interesting areas of the Indian subcontinent could be surveyed, yielding considerable data on Indian Drosophilidae (See Gupta, 1974; Prakash and Reddy, 1977; Sajjan and Krishnamurthy, 1975; Dwivedi *et al.*, 1979; Singh and Gupta, 1981; Gai and Krishnamurthy, 1982). However, a vast area of the subcontinent still awaits exploration. Parshad and Duggal (1966) carried out some field collections in different places of Kashmir valley. These studies yielded a total of twenty species including *D. pentaspina, D. epiobscura* and *D. ebonata* detected as the new species. This paper embodies the results of our recent field collections carried out in this region during June 1983.

The species under study were largely collected by net-sweeping over leaf foliage, fallen flowers, decaying fruits and also by using different fermenting fruits as bait in small containers. The metaphase chromosome preparations were made from the neuroblast cells of the third instar larvae following air-dried technique of Guest and Hsu (1973).

Genus Drosophila, Fallen

Drosophila Fallen 1823, Geomyzides Sueciae 2:4. Type-species: *Musca funebris* Fabricius; Sweden.

Subgenus *Drosophila* Fallen, S. Sr.

Drosophila Fallen 1823, Geomyzides Sueciae 2:4. Type-species : *Musca funebris* Fabricius; SWEDEN; Sturtevant 1939, Proc. Nat. Acad. Sci. 25:139; Sturtevant 1942, Univ. Texas Publ. 4213:30,

The *polychaeta* species group

Reddish brown species; three pairs of post-sutural dorsocentral bristles; large elliptical aedeagus; ventral receptacle relatively short and loosely coiled.

Drosophila (Drosophila) kashmirensis sp. nov.

Male and female : Average body length of male 2.8 mm and of female 3.09 mm. Arista with 3–4 dorsal and 2 ventral branches in addition to the terminal fork. Antennae with second segment brown; third segment little darker. Frons including ocellar triangle brownish. Orbitals in ratio of 12:7:17. Second oral bristle half the length of first oral bristle. Palpi brown, with one prominent apical seta. Carina light brown, greatest width of cheek one-fifth greatest diameter of eye. Clypeus dark. Eyes dark red.

Acrostichal hairs regular, in eight rows. Anterior scutellars convergent; posterior ones crossing each other. One additional pair of bristles in the line of dorsocentrals present. Anterior dorsocentral subequal to the posterior dorsocentral; distance between anterior and posterior dorsocentral 3/5 of the distance between two anterior dorsocentrals. Mesonotum and scutellum gray, becoming slightly darker with age. Humerals two, equal. Thoracic pleura yellowsh brown sterno-index 0.76.

Legs yellowish brown. Preapicals on all three tibiae; apicals on first and second tibiae.

Abdomen, tergites shiny yellow, with well developed dark brown apical bands, broadly interrupted medially.

Wings (Fig. 1, D): Clear, posterior crossveins distinctly darker. Two unequal bristles on the apex of first costal section; heavy bristles on about basal two-thirds of third costal section.

	C-index	4V-index	4C-index	5X-index
♂	3.14	2.10	0.97	1.5
♀	3.09	2.13	0.89	1.4

Halteres shiny yellow. Average wing length in male 2.86 mm and in female 3.06 mm.

Periphallic organs (Fig. 1, A) : Epandrium pubescent, pale yellow, narrow, triangularly pointed at lower tip and with about 17 marginal bristles. Surstylus much broader than long, with 9 stout large black teeth arranged in a straight row on outer margin and with 3 ventral setae. Cerci pubescent, fusiform, separated from genital arch, upper portion with about 25 bristles, lower tip narrowing and with 5–6 stout setae.

Phallic organs (Fig. 1, B): Aedeagus pale yellow, large and elliptical, with narrowly rounded tip apically, basal

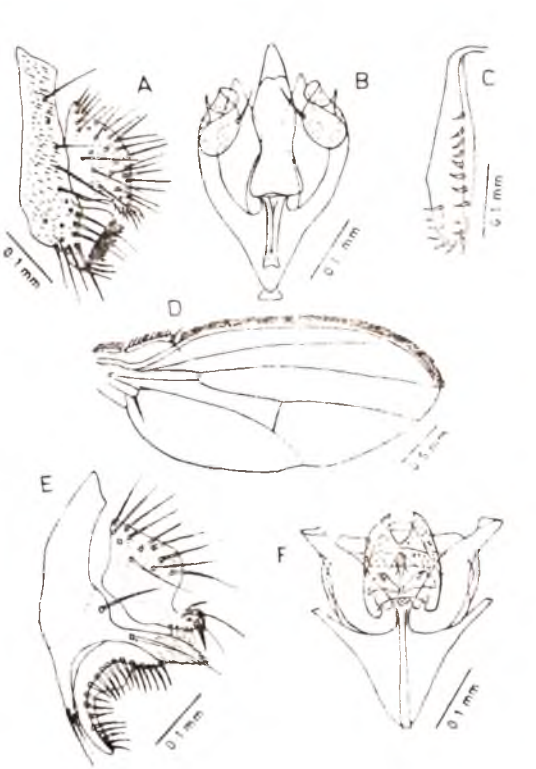

Fig. 1: *Drosophila kashmirensis* Sp. nov: A, Periphallic organs; B, Phallic organs; C, Egg-guide; D, Wing ♂; *Scaptomyza himalayana* Takada; E. Periphallic organs; F, Phallic organs.

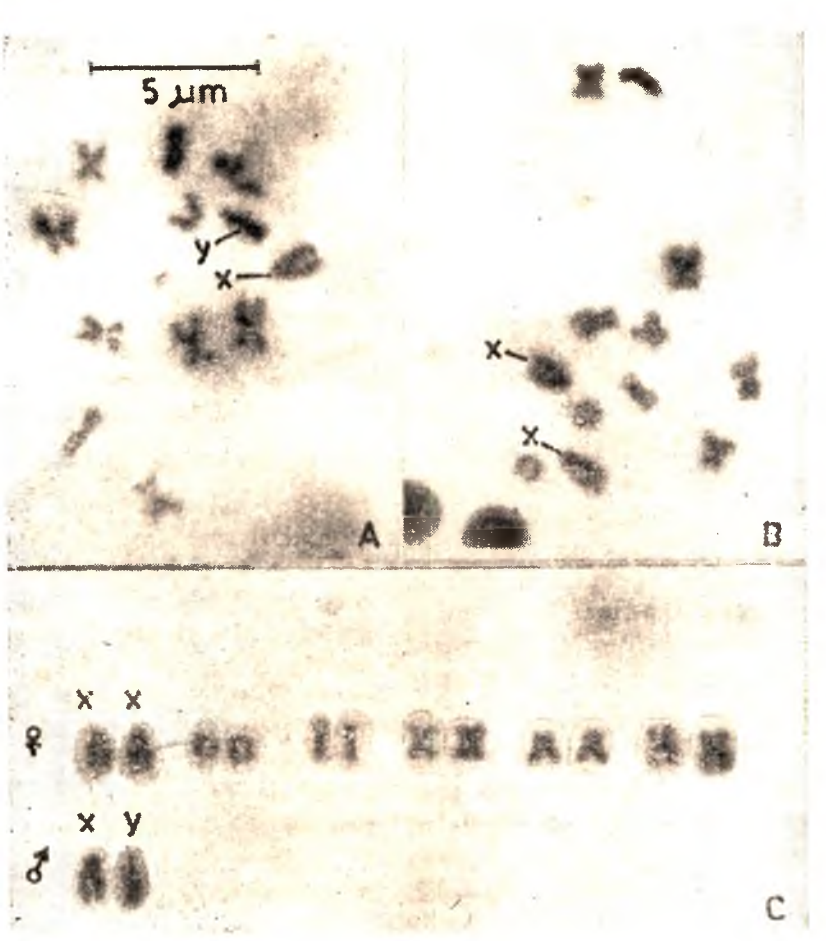

Fig. 2: Metaphase chromosomes of *Drosophila kashmirensis*: A, male plate; B, female plate; C, karyotype of male and female.

apodeme of aedeagus short, about half the length of aedeagus. Anterior gonapophyses large and without sensilla. Posterior gonapophyses obscure. Novasternum with a pair of submedian spines. Ventral fragma narrow, triangular.

Egg-guide (Fig. 1, C): Lobe yellowish, narrowing proximally and broadly rounded distally, with 14 marginal and 4 discal brown teeth. Basal isthmus narrow.

Holotype: One male from Shalimar Garden, KASHMIR, INDIA June, 1983, Collectors Kumar and Gupta.

Paratypes: 20 ♂♂, 17 ♀♀, collection data same as holotype.

All type species are at present deposited in the "*Drosophila* Collection" Deptt. of Zoology, Banaras Hindu University, VARANASI, INDIA. 4 ♂♂ and 3 ♀♀ from the paratype series are also deposited in the '*Drosophila* collection" of the Department of Biology, Tokyo Metropolitan University, Setagaya-Ku, JAPAN.

Chromosomes (Fig. 2): The chromosome number in this species as revealed by air-dried technique consists of $2n=12$, comprising 2 unequal pairs of rods, 1 pair of metacentric and 3 unequal pairs of submetacentric chromosomes. The *X* and the *Y* chromosomes represent the larger pair of rods, the *Y* being completely hetero-chromatic.

Relationship: The presence of three pairs of post-sutural dorsocentral bristles and its large elliptical aedeagus warrant its inclusion in the *polychaeta* species group of genus *Drosophila*, where it closely resembles *D. polychaeta* Patterson and Wheeler in having identical rows of acrostichal hairs, second oral bristle half the length of first oral bristle, but distinctly differs from it in having well developed dark brown abdominal bands (abdomen grayish brown uniformly in *polychaeta)*, and narrow triangular ventral fragma (broad in *polychaeta)*.

The above relationship has been further strengthened on the basis of chromosomes. Since both the species possess chromosome number $2n = 12$. However, the present species clearly differs from *D. polychaeta* in having a small pair of submetacentric chromosomes instead of a pair of dot chromosomes.

Distribution: INDIA.

Genus *Scaptomyza* Hardy

Scaptomyza Hardy, 1849. Berwickshire Nat. Club. Proc. 361. Type-species: *Scaptomyza graminum* Fallén; EUROPE.

Parascaptomyza Duda, 1924 Arch. Naturgesch. 90A(3):203. Type-species: *Drosophila pallida* Zetterstedt: EUROPE.

Scaptomyza (Parascaptomyza) himalayana Takada

Male and *Female:* Antennae with second segment brownish black; third segment pale brown. Frons including ocellar triangle dark brown. Face and cheek yellowish brown, greatest width of cheek one-fifth greatest diameter of eye.

Anterior dorsocentral, little smaller than the posterior one; distance between anterior and posterior dorsocentrals about 5/8 of the distance between two anterior dorsocentrals. Other details as described by Takada (1970).

Periphallic organs (Fig. 1, E): Genital arch yellowish brown, lower portion of genital arch narrow having two large bristles; posterior margin with a long conical process at middle, with two apartly placed basal bristles, under margin concave. Anal plate pubescent, upper portion with 11 large bristles; lower portion protruded in the form of secondary clasper, having 3 teeth at tip, lower one largest, upper portion with two large hairs; lower portion with 4–5 fine setae. Clasper bow-shaped, with a row of about 20 long bristles like teeth.

Phallic organs (Fig. 1, F): Aedeagus pale yellow, compact, apically notched, connected with a transverse membrane and covered with several wart-like structures. Anterior parameres small, dark brown, with about 3 apical sensilla. Hypandrium with large processes obliquely truncate apically. Ventral fragma slightly longer than broad, anteriorly with lateral projections.

Specimens examined: 100 ♂♂, 42 ♀♀ Gulmarg, 52 ♂♂ and 77 ♀♀ Shalimar Garden, Kashmir Vally. June 1983.

Distribution: NEPAL, JAPAN and INDIA (new record).

KEY TO SPECIES OF THE *POLYCHAETA* SPECIES GROUP

1 4V-index below 2.0.....*illota* Williston

— 4V-index 2.0 or above 2.0..... 2

2 Legs dark brown.....
.....*asper* Lin and Tseng

— Legs yellowish or yellowish brown.....
..... 3

3 Abdomen grayish brown uniformly, without distinct apical bands.....
.....*Polychaeta* Patterson and Wheeler

— Abdomen yellowish, with well developed dark brown medially interrupted apical bands.....*kashmirensis* Sp. nov.

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HISTOPATHOLOGICAL EFFECTS OF X-IRRADIATION ON THE TESTES OF THE RED COTTON BUG, *DYSDERCUS KOENIGII* FABR. (HETEROPTERA : PYRRHOCORIDAE)

K. P. SRIVASTAVA, D. J. DESHPANDE & R. L. KATIYAR

Department of Zoology, Banaras Hindu University, Varanasi, India 221 005

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The effects of X-irradiation on the testes of *D. konenigii* show up first in younger cells of the terminal regions of the testis follicle and progressively spread backwards to the older cells in the order spermatogonia, spermatocytes, spermatids and spermatozoa. By day 20 postemergence the testes are completely dystrophied and rendered non-functional. *(Key words:* X-irradiation, testes, histopathology, *D. koenigii)*

INTRODUCTION

While several studies on the effects of ionising radiations have been carried out in insects of other orders (see THEUNISSEN, 1977 for references), hemipterans, one of the most injurious of the insect pests have remained ignored. We have earlier published the effects of X-irradiation on the ovaries of *D. koeniigi* (SRIVASTAVA & DESHPANDE, 1983). In the present paper, we describe the long range effects of this energy on the testes of this insect.

MATERIALS AND METHODS

One day old 5th (ultimate) instar male larvae of *D. koenigii* having six days instar duration were exposed to a predetermined sterilising dose of 4000 rad of shoft X-rays by the procedure described earlier (SRIVASTAVA & DESHPANDE, 1983). Emerging adults were sacrificed on days 1, 3, 5, 10, 15 and 20 postemergence and their testes removed in insect Ringer (EPHRUSSI & BEADLE, 1936), fixed in Bouin's fluid, processed, sectioned at 7.5 μm stained in Heidenhain's haematoxylin and counterstained in eosin for histological observations.

RESULTSS

The normal histology of a mature testis with which the irradiation injuries have been compared is depicted in Fig. 1. In day 1 adult (7 days post-irradiation (pi), only the terminal spermatogonia seem to be affected with nuclear degenerative symptoms such as pycnosis, karyorrhexis and hyperchromatosis (Fig. 2) which being first to appear could be regarded as early radiation symptoms. Other germ cells and somatic elements remain unaffected. On day 3 (9 days pi), the primary spermatogonia develop additional symptoms of chromatolysis, karyolysis and cytolysis, the latter resulting in the formation of empty spaces at the apices of the testis follicles (Fig. 3). The secondary spermatogonia show only the early radiation symptoms which indicates that the degenerative symptoms appear at a slower pace in these cells than in their forerunners. In the primary spermatocytes, besides some of the above symptoms, blocked division (arrested metaphases) can also

be seen (Fig. 4). Pycnosis and chromatolysis now also appear in the secondary spermatocytes and the spermatids develop ghost nuclei (Fig. 5) while the spermatozoa remain still unaffected. On day 5 (11 days pi), there occurs a considerable loss of the primary spermatogonia so that the empty spaces which started appearing earlier now occupy larger (apical) areas of the testis follicles (Fig. 6). In the secondary spermatogonia, the degenerative symptoms found on day 3, now spreads to most of these cells. While the primary spermatocytes change their staining affinity from basophilic to acidophilic (chromatokinesis), the secondary spermatocytes start losing their compact arrangement inside the cysts (Fig. 7 cf. Fig. 2) and their pycnotic and karyorrhexic nuclei undergo karyolysis. On day 10 (16 days pi), the primary spermatogonia are completely lost and replaced by the cysted secondary spermatogonia by metaplasia (Fig. 8). Degenerative symptoms now spread to a large number of primary spermatocytes with the cyst wall breaking down at places (Fig. 9). The secondary spermatocytes show advanced stages of their (earlier) radiation pathology symptoms and hypertrophy in many cells. Ghost nuclei appearing earlier in the spermatids persist in the spermatozoa. The testis sheath gets thickened all over, excessively at the apices to appear tumorous (Fig. 8). On day 15 (21 days pi), the entire zone of spermatogonia is lost and replaced by the primary spermatocytes which show extensive cytolysis (Fig. 10). On day 20 (26 days pi), except for a few remnants of the secondary spermatocytes, identities of different constituents of the testis follicles are also lost, the testis sheath becomes thin again and the testes, completely dystrophied (Fig. 11).

DISCUSSION

The changes induced by X-irradiation in the present insect differ in some respects from those induced by X- and r-radiations. For instance a thickening in the testes sheath as a result of exposure to ionising radiations in other insects (THEUNISSEN, 1977; ASHRAF *et al.*, 1914) has been attributed to an increase in cell number (VINSON *et al.*, 1969) and has not been shown to be followed by a subsequent thinning. In the present insect, it is clearly the result of hypertrophy in the sheath cells (see Fig. 8) and is later followed by a thinning caused by cytolysis setting in these cells. Also a tumor-like growth due to extreme cellular hypertrophy caused only in one part of testis sheath in this insect points to the existence of differential radiosensitivity in this tissue the reason for which cannot be known.

Comparing the radiosensitivity of different germ cells, we observe that the radiosensitivity declines in the order spermatogonia, spermatocytes, spermatids and spermatozoa. Further a complete replacement of one cell type by another (metaplasia) such as spermatogonia by spermatocytes as observed in the present insect, has also been reported in the dipteran, *Hylemya antiqua* (THEUNISSEN, 1977). This is an indication of extreme radiosensitivity for any tissue. Occurrence of ghost nuclei is reported in 3 categories of cells in *H. antiqua:* spermatocytes, spermatids and spermatozoa (THEUNISSEN, 1977). In the present insect it occurs only in the latter two. Also no radiation induced giant spermatids or spermatozoa reported in some other insects (THEUNISSEN, 1977; CREIGHTON & EVANS, 1941; AMERSEKERE *el al.*, 1971) are found in the present insect despite the occurrence

Fig. 1. L. S. of a mature unirradiated testis to show the distribution of its somatic and germ cells. Top zone, ×225; the rest, ×325.

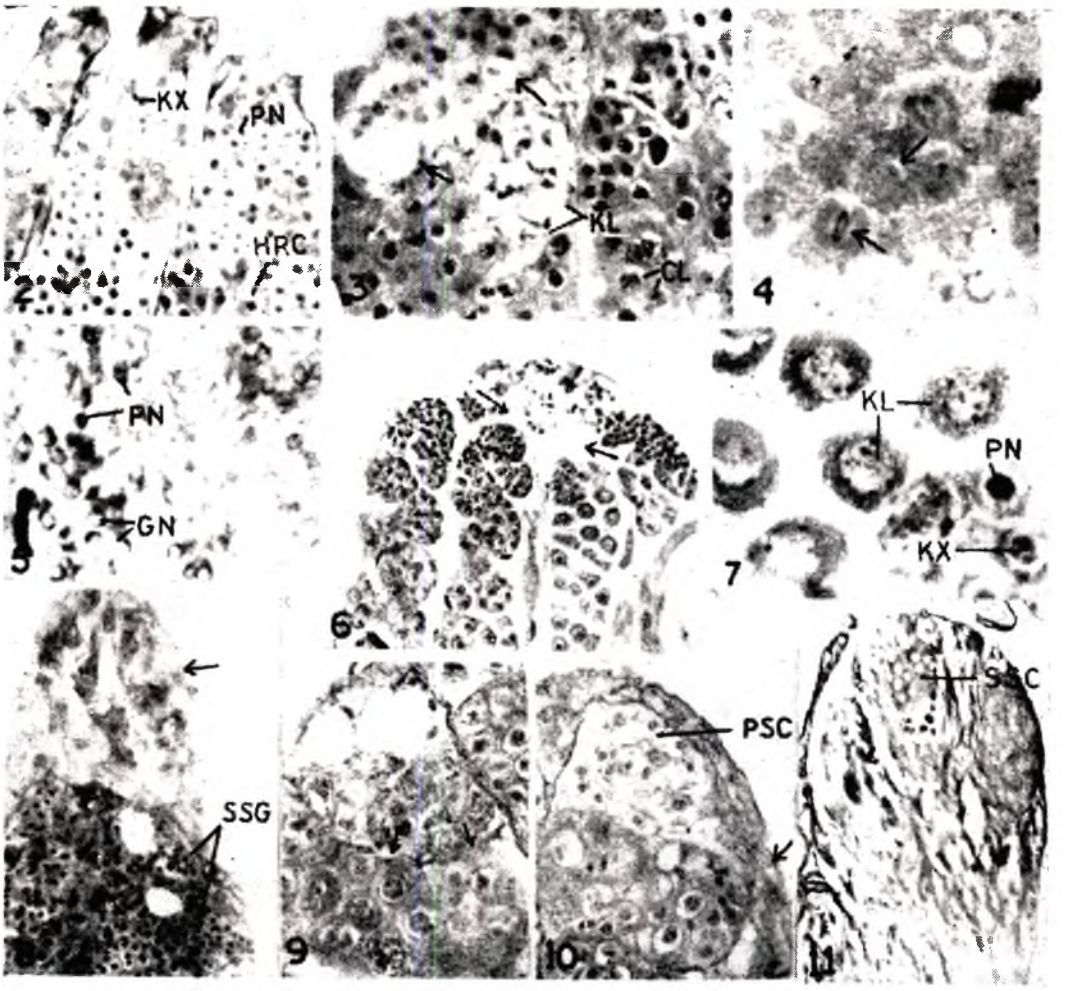

Fig. 2. Apical portion of the testis follicle with primary spermatogonia showing pycnosis, karyorrhexis and hyperchromatosis. ×245. Fig. 3. Primary spermatogonia showing chromatolysis, karyolysis and empty spaces (arrows) resulting from cell cytolysis. ×350. Fig. 4. Primary spermatocytes showing blocked divisions (arrows). ×525. Fig. 5. Spermatids showing pycnosis and ghost nuclei. ×525. Fig. 6. Apical portion of the testis follicles with more empty spaces (arrows) due to greater loss of primary spermatogonia. ×245. Fig. 7. Loosely arranged secondary spermatocytes showing pycnosis, karyorrhexis and karyolysis. ×525. Fig. 8. Apical portion of the testis follicles showing replacement of primary spermatogonia by the secondary ones, empty spaces and tumorous nature of the testis sheath. ×245. Fig. 9. Breakdown of cyst walls around primary spermatocytes (arrows). ×450. Fig. 10. Primary spermatocytes replacing spermatogonia and undergoing cytolysis. Note also the thickened testis sheath (arrow). ×350. Fig. 11. A highly dystrophied testis in which nothing except a few spermatocytes can be identified. Note also the thinned down testis sheath (arrow). ×175.

of hypertrophy in some of the secondary spermatocytes. Obviously, the latter degenerate before maturation in this insect.

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COMBINED EFFECT OF MALATHION AND PIPERONYL BUTOXIDE ON *PERIPLANETA AMERICANA* L. : AN ASSESSMENT BASED ON KNOCK-DOWN RESPONSE AND HISTOPATHOLOGICAL OBSERVATIONS

S. C. SAXENA & PRABHU N. SAXENA

Toxicology Section, Department of Zoology, University of Rajasthan, Jaipur, India 302 004

(Received 21 September 1984)

Pathological lesions in *Periplaneta* brain after treatment with malathion-mixed piperonyl butoxide bring about knock-down much earlier than by individual treatments. Hence brain has been considered site of action for both, which has been discussed in relation to penetration.

(Key words: Periplaneta americana, malathion, piperonyl butoxide, synergism)

INTRODUCTION

Though combined effect of insecticides with different synergists is an established fact (SUN & JOHNSON, 1972), little information on histopathological alterations resulting from the combined action of synergist and insecticide, is available. In the present paper pathogenicity in the target organ, the brain, along with knockdown response caused due to synergised malathion is dealt with.

MATERIALS AND METHODS

Malathion and piperonyl butoxide (1% solution in acetone) were mixed in equal volume (1:1 v/v). The mixture, 0.01 ml, was applied topically to the forefemur of newly emerged adult cockroaches of both the sexes. 30 insects were treated in each category. The replicates and controls with 1% piperonyl butoxide and solvent (0.01 ml acetone) were also run separately. The time taken for knock-down was recorded. To observe histological changes, brains along with abdominal and thoracic ganglia were fixed in histowax, at 30 min, 1 h and 2h after treatment. In each case 6μm sections were cut and were stained with haematoxylin and eosin.

RESULTS AND DISCUSSION

The periods after which the knock-down was observed in the cockroaches treated with malathion + piperonyl butoxide, as well as with piperonyl butoxide-malathion and acetone separately are given in Table 1. No pathological changes in the brain is observed on treatment with the solvent (acetone) alone. Also, no pathological alteration is evident in the brain of piperonyl butoxide-treated roaches, except slight vacuolization. Further, no change has been observed in thoracic and abdominal ganglia (SAXENA, 1982).

Pathological changes in the brain on treatment with piperonyl butoxide

No significant change except a slight vacuolization is observed.

On treatment with malathion

30 minutes after treatment: The connective tissue sheath remains intact with the underlying glial cells. There is no indication of fibre degeneration. The

TABLE 1. Knock-down of *Periplaneta americana* L. treated with malathion and piperonyl butoxide applied topically (0.01 ml/insect) to foreiemur.

Time* in minutes for knock-down			
Acetone	Piperonylbutoxide + Acetone	Piperonyl butoxide 1% + Malathion 1% (1:1 v/v)	Malathion 1%
675 ± 9.34	72.12 ± 6.55	39.14 ± 2.54	24.14 ± 1.16
			P.01

* Mean of 30 individuals.

glial cells do not exhibit any significant change but the vacuoles appear around the calyces (Fig. 1).

1 hour after treatment: Fibrous degeneration is well marked. The vacuolization is more intense (Fig. 2).

2 hours after treatment: The vacuolization is extensive and the cell body of neurosecretory cells is filled with nuclear material (Fig. 3).

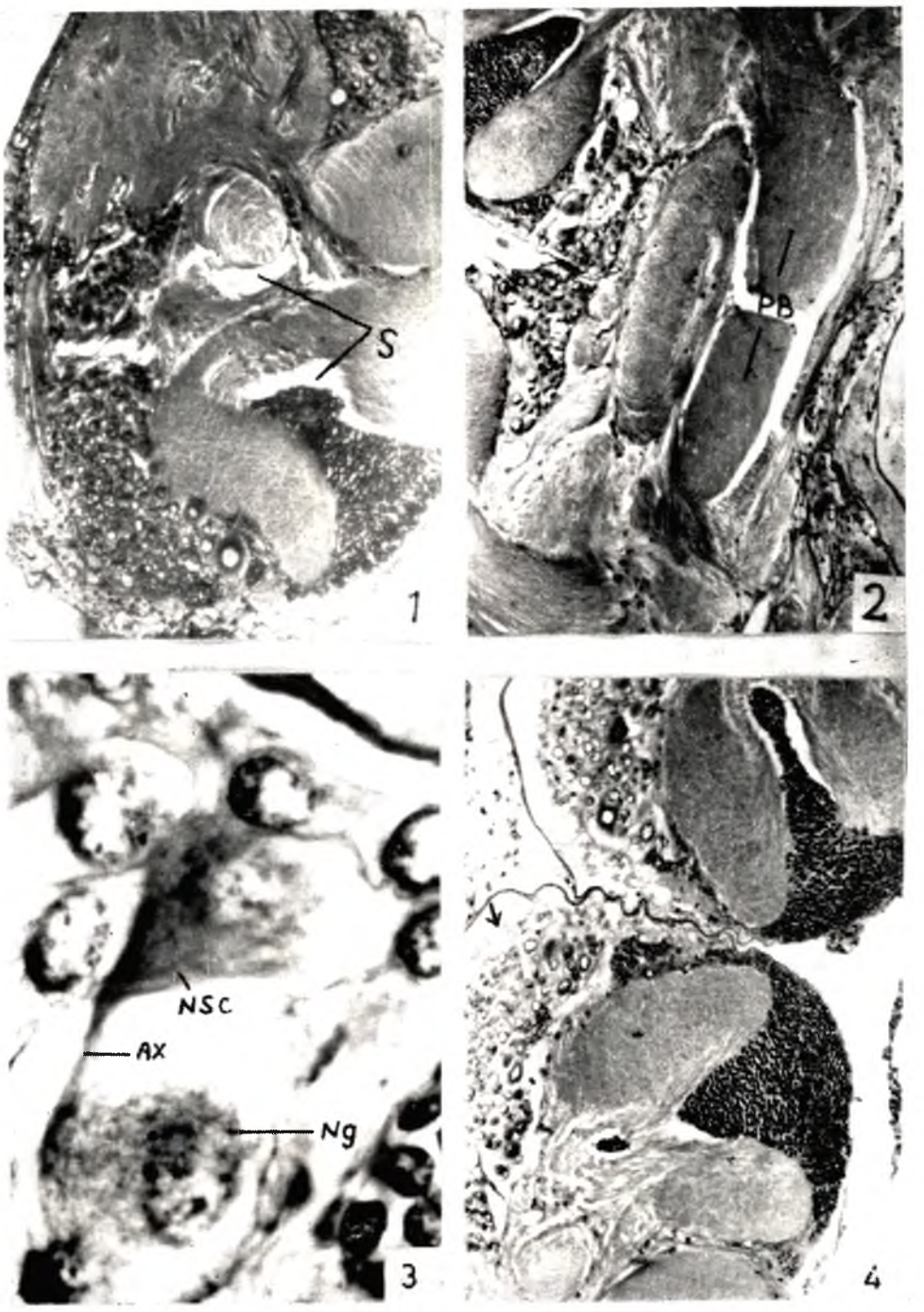
On treatment with malathion mixed with piperonyl butoxide

30 minutes after treatment: The connective tissue sheath remains intact with the underlying glial cells; chromatolysis is observed in neuronal nucleus (Fig. 4). Fibrous degeneration is very well marked (Fig. 5). There is extensive vacuolization all around the nerve cell nucleus (Fig. 6).

1 hour after treatment: The fibrous degeneration is extensive (Fig. 7). A blank space is left in between glial cells and connective tissue sheath (Figs. 8, 9).

2 hours after treatment: The vacuolization is extensive and the fibrous degeneration has almost changed the regular pattern of arrangement of fibres (Fig. 10). The cell bodies of the neurosecretory cells show complete chromatolysis. Vacuolization is extensive all around the neurosecretory cells (Fig. 11). After 2 hours, the glial cells cover almost whole of the fibrous portion. These glial cells clump together forming a black mass (Fig. 12).

The quick knock-down and high intensity of pathological changes on treatment with malathion mixed piperonyl butoxide as compared to malathion alone indicates that piperonyl butoxide synergises malathion and thereby the effect is more intense. An early knock-down on treatment with malathion mixed with piperonyl butoxide in the ratio of 1 : 1 as compared to malathion and piperonyl butoxide applied separately shows that piperonyl butoxide acts as a synergist with malathion by either easing the entry of malathion into the insect body or preventing the deterioration of the toxicant within the body or increasing the effectiveness of malathion in mixture so that the quick knockdown leading to death is the consequence. Qualitatively, synergism between piperonyl butoxide and one of the organophosphorus compounds diazinon on diptrex has been reported (RAI & ROAN, 1956). HOFFMAN *et al.* (1954) also observed synergism



Photomicrograph of brain of *Periplaneta americana* L.

Fig. 1. After 30 minutes of malathion treatment showing vacuolization all around calyces. ×100. Fig. 2. After 1 hour of malathion treatment showing spaces around protocerebral bridge. ×100. Fig. 3. After 2 hour of malathion treatment showing neurosecretory granules (Ng) in the neurosecretory cells (nsc) and axon (ax). ×950. Fig. 4. After 30 minutes of piperonyl butoxide + malathion treatment showing globuli cells (arrow) towards the centre. ×100.

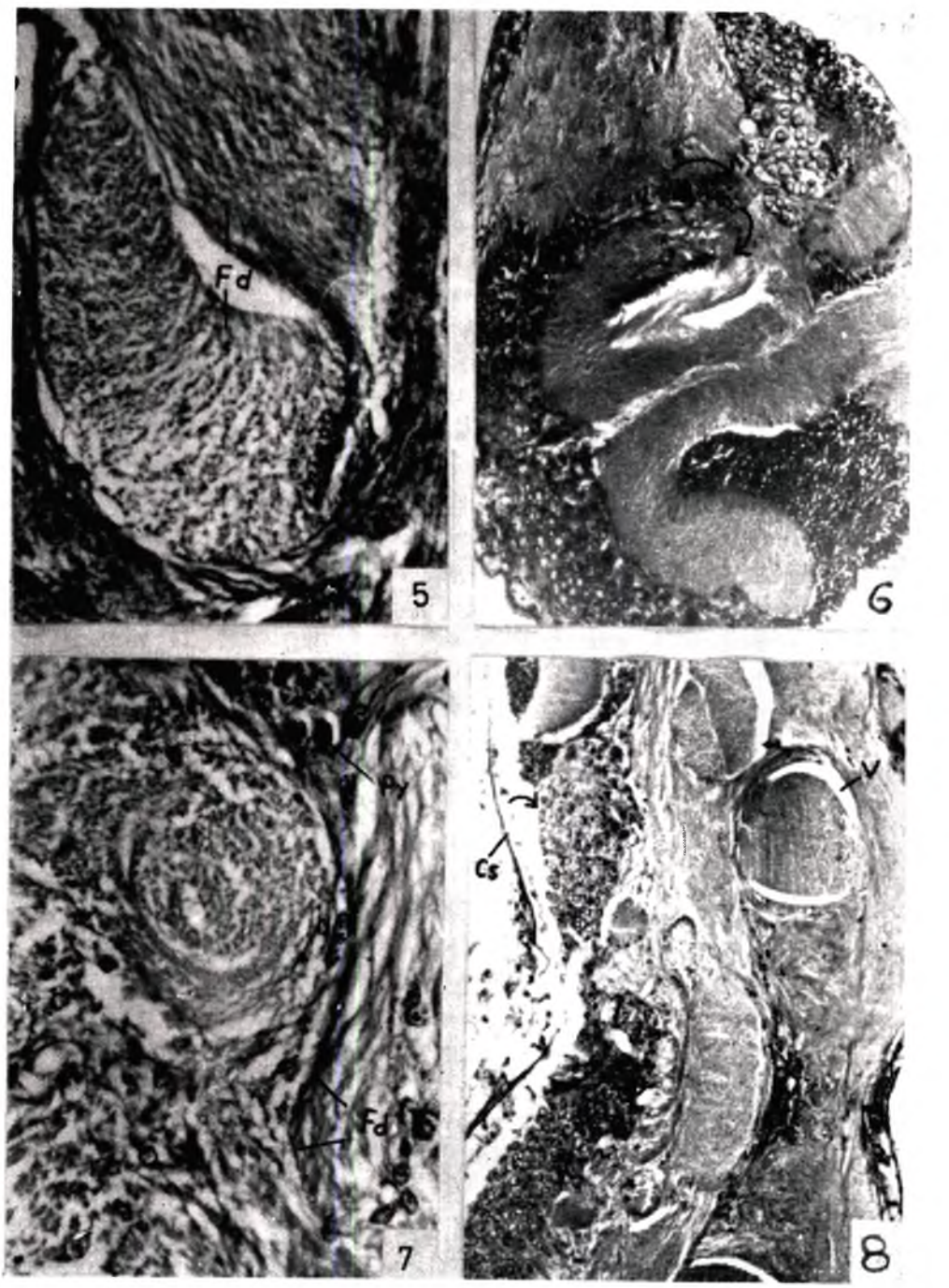


Fig. 5. After 30 minutes of piperonyl butoxide + malathion treatment showing extensive fibrous degeneration (Fd). ×950. Fig. 6. After 30 minutes of piperonyl butoxide + malathion treatment showing glial cells (arrow) in the spaces formed inside the calyces. × 100. Fig. 7. After 1 hour of piperonyl-butoxide + malathion treatment showing extensive fibrous degeneration (Fd) and pycnosis (Py) in the neuronal cell nuclei ×950. Fig. 8. After 1 hour of piperonyl-butoxide + malathion treatment showing separation of glial cell mass from connective tissue sheath (Cs) (by arrow) and vacuolization (V) around calyces. ×100.

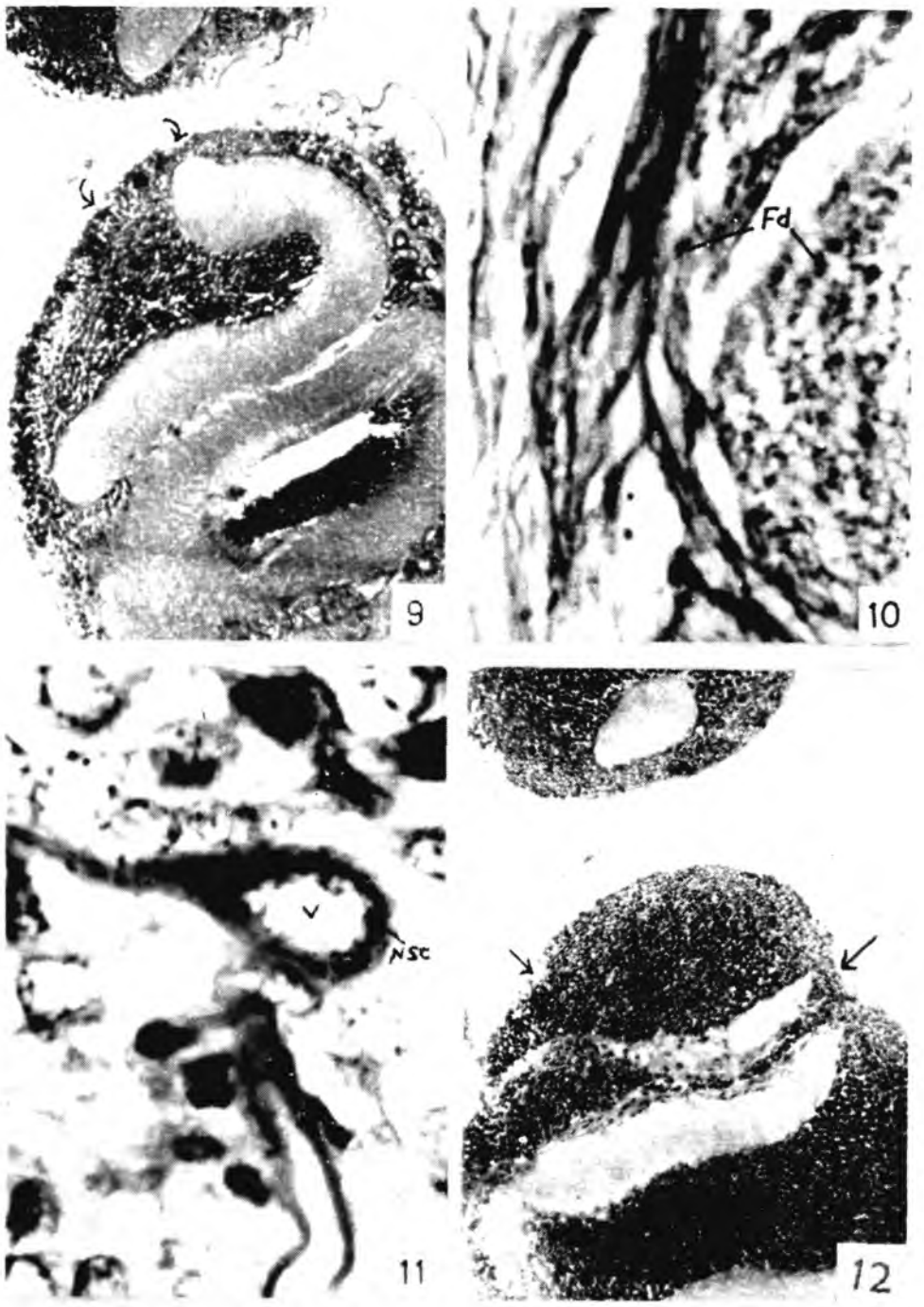


Fig. 9. After 1 hour of piperonyl-butoxide + malathion treatment showing glial cells towards the centre (arrow). ×100. Fig. 10. After 2 hours of piperonyl-butoxide + malathion treatment showing fibrous degeneration which has almost changed the regular fibrillar pattern. ×950. Fig. 11. After 2 hours of piperonyl-butoxide + malathion treatment showing spacious vacuoles inside the neuro-secretory cell and complete chromatolysis of nuclear material. ×950. Fig. 12. After 2 hours of piperonyl batoxide + malathion treatment showing extensive infiltration ×100.

of 7 organophosphates by 19 non-phosphorus compounds and recorded mortality of insects when the synergist and the compound were mixed in the ratio of 1:5. Earlier ZCHINTSCH (1961) (see O'BRIEN, 1967) has shown synergistic activity of piperonyl butoxide with malathion, parathion and diazinon at low organophosphorus concentration. The quick knock-down could be attributed to inhibition in the enzyme activity which is responsible for insecticidal detoxication when the synergist piperonyl butoxide is added to malathion. If the detoxication is inhibited, obviously more quantity of insecticides will be available for knockdown of insects. This suggestion finds support from the findings of earlier workers viz., METCALF (1967), BROOKS (1968) and CASIDA (1970). SUN & JOHNSON (1972) also propounded that synergistic action is a result of inhibition in the activity of enzymes responsible for insecticidal detoxication.

Further the higher intensity of pathological changes in the brain including infiltration of peripherally placed glial cells towards the centre, fibrous degeneration and complete chromatolysis in the cell body of neurosecretory cells on treatment with malathion + piperonyl butoxide may be considered to be due to the synergistic action, since such changes are not at all observed in insects treated with either piperonyl butoxide or with malathion. HARTZELL & SUDDER (1942) and HARTZELL (1945) also observed pathological changes as a result of synergism and concluded that these histological effects are probably of secondary importance as a cause of death and the primary reason may be assigned to biochemical lesions in the nervous system. It is also possible that both the insecticide and synergist, whenever are mixed, probably act on a similar site of action so that the effect turns out to be cumulative thereby resulting in an increase in the intensity of effect manifested by quick knock-down. NAIDU (1965) reported that for both malathion and piperonyl butoxide, the site of action is the same. The quick knock-down and high intensity of pathological changes also suggest that penetration might have been more on treatment with malathion mixed with piperonylbutoxide. But it needs further exploration to establish whether piperonyl butoxide eases the entry of insecticides at the external barrier, the integument or at the internal barrier, the connective tissue sheath present around the site of action, the brain. If the penetration is favourably affected as suggested, one of the consequences will certainly be a quick knock-down.

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PRECOCENE - II AND THE SECRETORY RHYTHM OF THE MEDIAN NEUROSECRETORY CELLS IN THE SEMILOOPER CATERPILLAR, *ACHOEA JANATA* (L.)

D. MOHANAKUMAR* & D. MURALEEDHARAN

Department of Zoology, University of Kerala, Kariavattom, India 695 581

(Received 25 August 1984)

A circadian rhythmic pattern of activity is noticed in the median neurosecretory cells of the pars intercerebralis region of 4th and 5th instar caterpillars of *Achoea janata* subjected to LD 12:12 cycle. The activity is at a minimal level during 0 to 8 h reaching gradually its peak level at 16 h with a subsequent drop at 18 to 24 h. Altered LD cycle (18:6) shifts peak level of activity from 16 to 18 h. In the larvae of both the instars, treatment with precocene-II causes a significant reduction in the neurosecretory activity in addition to complete disruption of the rhythmic activity pattern.

(Key words: Achoea janata, precocene, rhythm, neurosecretion)

INTRODUCTION

Involvement of circadian rhythmicity in the secretion of insect neurohormones now appears to be a general phenomenon following the classical work by some of the researchers (PITTENDRIGH, 1966; TRUMAN, 1971 a, b; FUJISHITA & ISHIZAKI, 1981, 1982). A gated release of prothoracicotropic hormone (PTTH) causes larval ecdysial rhythm in *Manduca sexta* (TRUMAN, 1972) and the induction of prodromal signs of pupation in this insect is confirmed by TRUMAN & RIDDIFORD (1974). Rhythmicity in the endocrines is reflected in the size and activity of the neurosecretory cells in the brain (BRADY, 1967). The rhythmic nature of synthesis and release of eclosion hormone, bursicon, PTTH, calling hormone etc. are exhaustively discussed by TRUMAN (1978) in his recent review.

UNNITHAN *et al.* (1978) have demonstrated that in *Oncopeltus fasciatus* the A-type neurosecretory cells of pars intercerebralis, after treatment with precocene, showed substantial decrease in their secretory contents. However, MARTINEZ CARRAU *et al.* (1981) demonstrated heavy accumulation of stainable material in the A-cells of pars intercerebralis of precocene-treated females of *Lygaeus militaris* and *Oncopeltus fasciatus*. In the present studies the secretory rhythm of pars intercerebralis neurosecretory cells (PINSC) and the effect imparted by precocene-II (6-7-dimethoxy-2, 2-dimethyl chromene) on this rhythm in the semilooper caterpillar, *Achoea janata* are investigated.

MATERIALS AND METHODS

Insects used for the present investigations belong to the species *Achoea janata* (Lepidoptera : Noctuidae). The animals were maintained at a temperature 29 ± 3°C, RH 90 ± 3% and 12:12 light and dark regime. Caterpillars were allowed to feed on castor *(Ricinus communis)*

* Government Victoria College, Palghat, India.

leaves supplied fresh daily. The females laid eggs mostly under the castor leaves provided. The eggs were removed every day and were allowed to hatch. Newly emerged larvae were fed on fresh castor leaves *ad libitum*. Caterpillars of each instar found emerged in the same morning were separated and maintained on fresh leaves which provided enough larvae of the same age group for the experiments.

For investigating the activity rhythm of the A-cells, brains from 4th and 5th instar larvae were dissected out at 2 h interval during the entire larval period of 2 days for the 4th instar and 4 days for the 5th instar. Effect of prolonged photoperiod on the neurorecretory rhythm was studied using artificial light with 18 h photophase and 6 h scotophase.

Precocene-II (a gift from Prof. W. S. BOWERS, Geneva, U. S. A.) was used for investigating the effect of anti-allatin on PINSC activity. Effective doses of Precocene-II were determined from preliminary trials. Precocene-II dissolved in acetone (10µl acetone containing 50µg of precocene-II) was topically applied to the dorsal side of mildly anaesthetised 0—1 h old caterpillar with the help of a calibrated micro-glass capillary having a narrow rubber cannular attachment. Caterpillars of each instar emerged between 0—1 h of the day were used for this experiment. Controls were treated with acetone. After evaporating the acetone, larvae were transferred to plastic buckets with fresh castor leaves and reared under LD 12:12. Brains of the caterpillars from the experimental and control animals were dissected out at 2 h interval, as earlier.

Dissections were made in insect Ringer (EPHRUSSI & BEADLE, 1936) and brain fixed either in Bouin's fluid or in formal saline and paraffin sections (6µ) prepared were stained with either Chrome haematoxylin-phloxine (GOMORI, 1941) or with Aldehyde Fuchsin (CAMERON & STEELE, 1959). For whole mount preparations either the Performic acid-Victoria blue or Aldehyde Fuchsin technique as was used by DOGRA & TANDON (1964) was followed. Neurosecretory indices were calculated according to the method of JALAJA & PRABHU (1977). Measurements of the stained preparations were taken using a calibrated ocular micrometer. Values are mean from 5 larvae.

OBSERVATIONS

Three types of neurosecretory cells A, B and C are discernible in the brain of caterpillars of *Achoea janata* depending on their staining properties. The number of A-type neurosecretory cells present in the pars intercerebralis region of the brain varied from 4 to 10 in the larval instars. No striking difference from this pattern was noticed in the two instars studied.

A distinct rhythm as evidenced by significant change in the neurosecretory index, cell diameter and the diameter of the nuclei in these A-cells are noticed in both 4th and 5th instar caterpillars exposed to LD 12:12 during their entire life span. These three parameters are minimum during 0—8 h with a steady increase at 10 to 16 h reaching the peak level towards 16 h. During 18—24 h the activity shows a gradual decrease (Figs. 1 & 2). Since the same activity pattern was noticed in both the instars during the subsequent days, data pertaining to only the first 24 h is given in figures shown. Altered LD cycle (18:6) resulting in prolonged photophase slightly shifted the diel rhythm of activity. During photophase the pattern of activity remains almost the same as that in the normal except the fact that the peak level of activity was shifted from 16 h to 18 h on all days.

In both the instars, after precocene treatment, very little stainable material can be noticed in the A-type PINSC compared to that in the normal and acetone-treated control throughout (Figs. 1, 7 & 8). The cellular and nuclear diameters of the PINSC-A of treated individuals also show a decrease (Fig. 2). Thus precocene treatment completely upsets the normal rhythm

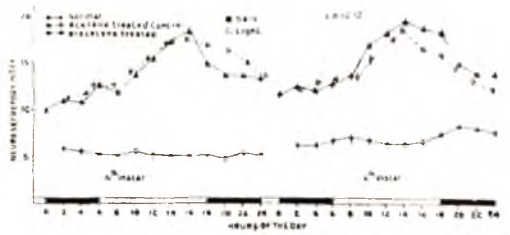


Fig. 1. Neurosecretory indices of A-type PINSC in the 4th and 5th instar caterpillars of *A. janata*. Each value represents mean of 5 individual observations and the bars are ± SEM.

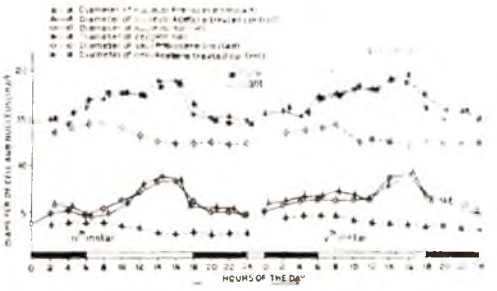


Fig. 2. Diameters of A-type PINSC and their corresponding nuclei in the 4th and 5th instar larvae of *A. janata*. Each value is mean from 5 individuals and the bars are ± SEM.

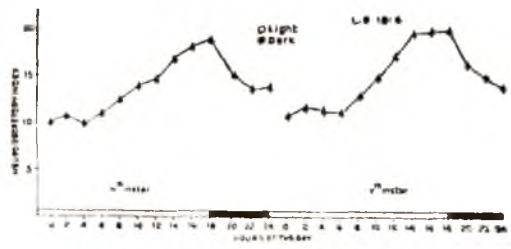


Fig. 3. Neurosecretsry index of A-type PINC in the 4th and 5th instar larvae of *A. janata* exposed to altered photoperiod. Each value denotes mean from 5 observations and the bars are ± SEM.

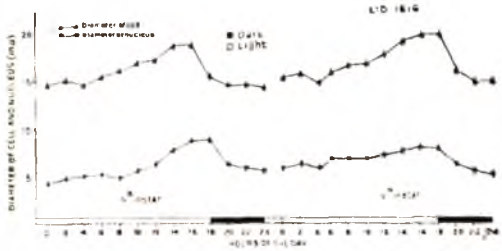


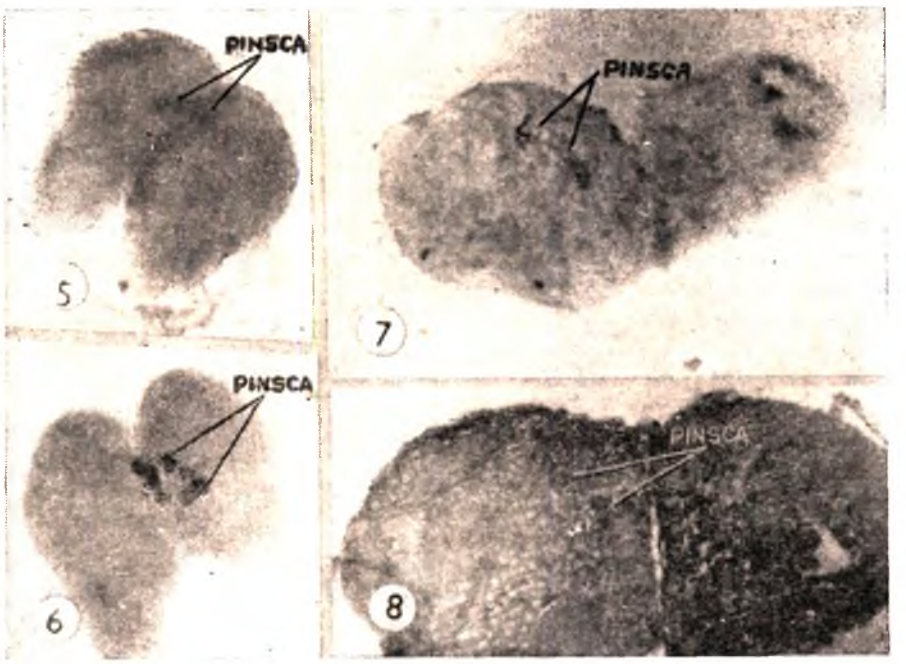
Fig. 4. Diameters of A-type PINSC and their respective nuclei in the 4th and 5th instar caterpillars of *A. janata* exposed to altered photoperiod. Each value represents mean from 5 determinations and the bars are ± SEM.

of neurosecretory activity showing a much lower and almost uniform pattern of activity (Fig. 2).

DISCUSSION

Awasthi & Singh (1982) described the morphological details of the different groups of neurosecretory cells in *Achoea janata* and all the 3 types of neurosecretory cells (A, B and C) are identifiable in the present preparations as well. Among these different groups, median neurosecretory cells in the pars intercerebralis region are the most prominent ones and present studies on the secretory rhythm are restricted to A-group cells. The diameter of the neurosecretory cells as well as their nuclei are taken into account in addition to the neurosecretory index for evaluating the activity of A-type PINSC.

In the caterpillars reared under LD 12:12 cycle, a clear rhythm can be noticed in the A-type PINSC activity. Activity is at a minimal level during 0—8 h. A steady inrease is noticed towards 10—16 h reaching a peak level at 16 h of the day. The same sort of rhythmic pattern of activity is noticed in the A-type PINSC of caterpillars



Figs. 5—8. Photomicrographs of stained preparations of brain of 4th and 5th instar caterpillars of *A. janata*. Fig. 5, Whole mount preparation of newly emerged 4th instar larvae at 02.00 h, AF, × 60, LD 12:12; Fig. 6, Whole mount preparation of 4th instar larvae at 16.00 h, AF, × 60, LD 12:12; Fig. 7, Section of brain of precocene-treated 5th instar larva at 16.00 h, CHP, × 125, LD 12:12; Fig 8, Section of brain of acetone-treated control at 16.00 h, CHP, × 125, LD 12:12. PINSCA, A-type pars intercerebralis neurosecretory cells.

exposed to prolonged photophase as well but with a slight shift in the time of peak level of activity. This sort of a circadian cycle of activity in the endocrine system has been noticed in a number of insect species such as *Carabus nemoralis*, *Ostrinia nubilalis*, *Drosophila melanogaster* and *Acheta domestica* (KLUG, 1958; BECK, 1964; RENSING, 1964; CYMBOROWSKI & DUTKOWSKI, 1969). According to TRUMAN (1978) the synthesis and release of hormones like eclosion hormone, bursicon PTTH and calling hormone are rhythmic. In *Ostrinia nubilalis* the neurosecretory cells of the brain show a well defined trimodal rhythm with a peak level of activity at 8—16 h. Observations on saturniid moth, *Samia cynthia ricini* by FUJISHITA & ISHIZAKI (1981) reveal the release of PTTH from the brain during the larval-larval ecdysis according to a well-defined rhythm.

Environmental cues like light can influence the secretory activity of the neurosecretory cells. For example in *Acheta domestica* it was found that the light conditions in which the insects have been reared influence the fine structure of the neurosecretory cells (CYMBOROWSKI & DUTKOWSKI, 1970).

In the present study, it was observed that the caterpillars reared in light/dark regime of 18:6 showed almost the same rhythm of A-type PINSC activity but with a slight phase shift in the peak level from 16 h to 18 h of the day.

Present studies also reveal the effect of precocene-II on the activity rhythm of A-type PINSC in *A. janata*. The neurosecretory index as well as the diameters of the cells and nuclei of these cells are much lower than that noticed in the normal as well that in the acetone-treated controls. Treated individuals show only very little accumulation of aldehyde fuchsin-positive material. These observations are in agreement with those of UNNITHAN *et al.* (1978) in *Oncopeltus fasciatus* in which treatment of precocene resulted in less stainable material in the A-cells of pars intercerebralis. They have suggested that the inhibition of activity of A-cell in the brain by precocene treatment can be due to the absence of a positive feedback from the corpus allatum on account of the allatocidal activity of precocene, which may also hold good for *A. janata* as well.

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INFLUENCE OF JUVENILE HORMONE ANALOGUE ON METAMORPHOSIS OF *PHILOSAMIA RICINI* HUTT. (LEPIDOPTERA : SATURNIIDAE)

V. B. AWASTHI

Department of Zoology, University of Jodhpur, Jodhpur, India

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Juvenile hormone analogue (AY-22-342-3) treatment to the last (5th) instar larva of *Philosamia ricini* indicated a number of morphological abnormalities such as 6-7 days larval duration prolonged to 17-24 days. Some larvae or prepupae survived for 24 days and died without metamorphosis; majority of them failed to spin cocoons and formed naked pupae; cocoons, if formed, were extremely thin, light in weight with 2 big valves. The pupae retained larval characters (malformed mouth parts and antennae) and were very fragile. The treated parts remain untanned in the subsequent moult. Although the pupae developed all the imaginal structures, the majority of them failed to emerge as moths and if the moths emerged, they failed to unfold their wings and showed a number of abnormal features.

(Key words: corpora allata, juvenile hormone, juvenile hormone analogues, *Philosamia ricini*, *Ricinus communis)*

INTRODUCTION

Several attempts have been made to study and elucidate the influence of juvenile hormone (JH) and juvenile hormone analogues (JHAs) on the metamorphosis in insects (SLAMA *et al.*, 1974; NOVAK, 1975) but no such information is available on erisilkworm, *Philosamia ricini*. In this work, the influence of exogenous treatment of JHA on the metamorphosis of *Philosamia ricini* Hutt. has been studied.

MATERIALS AND METHODS

Newly moulted healthy 5th instar larvae of *Philosamia ricini* were obtained from a culture, maintained on castor leaves *(Ricinus communis)* at room temperature (25 ± 5°C). The insects were divided into 4 groups : the first group normal) were given no treatment, the second group (control) allowed topical application of 12.5 µl of olive oil, the third group 25 µl JHA Ay-22-342-3 on day 3 and the fourth group 12.5 µl of JHA on day 3, 4 and 6.

OBSERVATIONS

The normal larvae, on day 6 or 7, spinned thick and leathery cocoons having only one narrow anterior valve (Fig. 1). The larvae evacuated their gut 2-days before spinning the cocoons. It was also observed, after dissecting the cocoons, that the pupae inside them were normal and brown in colour.

The larvae treated with 25 µl of JHA once only on day 3, constructed on days 8 and 9 extremely thin cocoons through which the prepupae were clearly seen (Fig. 2) and the site of JHA application in the pupae remained untanned (Fig. 3). The cocoons were provided with two wide-valves, one anterior and

the other posterior (Fig. 2). The anterior valve was more than 1.5 cm in diameter (Fig. 4). The head and wing pads showed malformations, the last abdominal segment of the treated pupae retained larval characters. The moths resulting from treated larvae failed to unfold their curly wings.

The larvae treated with 12.5 µl JHA on days 3, 4 and 6 indicated prolongation of larval life and inhibition of cocoon formation. The results were rather variable and not uniform in all the treated larvae (1) some of the larvae pupated without constructing cocoons (naked pupae); (ii) others constructed very thin and light cocoons with two big valves; (iii) and still others failed to pupate, survived for 24 days as larvae or prepupae (Fig. 5) and then died. The moths emerging from the treated larvae were not able to unfold their wings, the wings were short, thick and curly (Fig. 6). Moths also retained larval characters on the last abdominal segment (Fig. 6).

Further, the treated parts i.e., meso- and metasternum became fragile and along with a few anterior abdominal segments remained untanned throughout the pupal stage. These pupae retained larval head or abnormal head (Fig. 7), abdominal prolegs and larval characters in the last abdominal segment (Figs. 8, 9). The treated larvae also excreted a large amount of watery fluid continuously for about 10 days whereas the normal and the controls did not do so.

The moths emerging from the normal and control pupae were healthy (Fig. 10), the pupae of the treated larvae though formed all the imaginal structures, majority of them either failed to emerge as moths or abnormal moths emerged having abnormal and deformed head, antennae and wings.

The antennae appear bipectinate in the normal and control specimens (Fig. 11). However, the antennae of the resulting moths from the treated larvae show marked variation. (1) Either they develop bulbous base with terminal beads (Fig. 12) or they metamorphose in the form of a leaf-like structures with bristles at the margin (Fig. 13). In several cases the antennae of a side was different from that of the other side in the same individual. Such effects of JHA on the antinnae of *Antheraea polyphemus* have also been reported by SCHNEIDERMAN & GILBERT (1959).

DISCUSSION

In *Galleria mellonella* (SEHNAL & SCHNEIDERMAN, 1973; SEHNAL & MEYER, 1968) obsorved formation of superlarvae or intermediates due to the influence of JHA. No such superlarvae or intermediates have been observed in JHA treated individuals in *Philosamia ricini*. RIDDIFORD (1972) remarked that the high doses of JH applied daily did not result in a supernumerary larval moult.

The treated larvae failed to spin cocoons, they remained larvae or prepupae and survived as such for about 24 days. AKAI & KOBAYASHI (1971) have also remarked in case of *Bombyx mori* that at doses of JH between 1 and 10 µg JH/g body weight some insects remained as larvae for long period. In the case of 10 µg JH administration, some animals survived for 26 days in the 5th instar (although control animals pupated within 12 days). AKAI & KOBAYASHI (1971) have further observed that 10 µg JH treated insects never showed any sign of metamorphosis. Prolongation of larval period

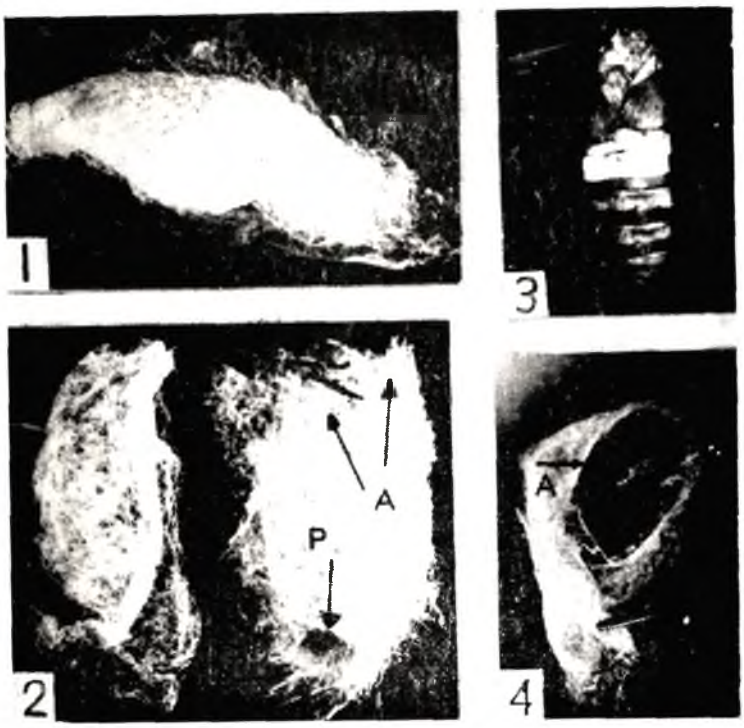
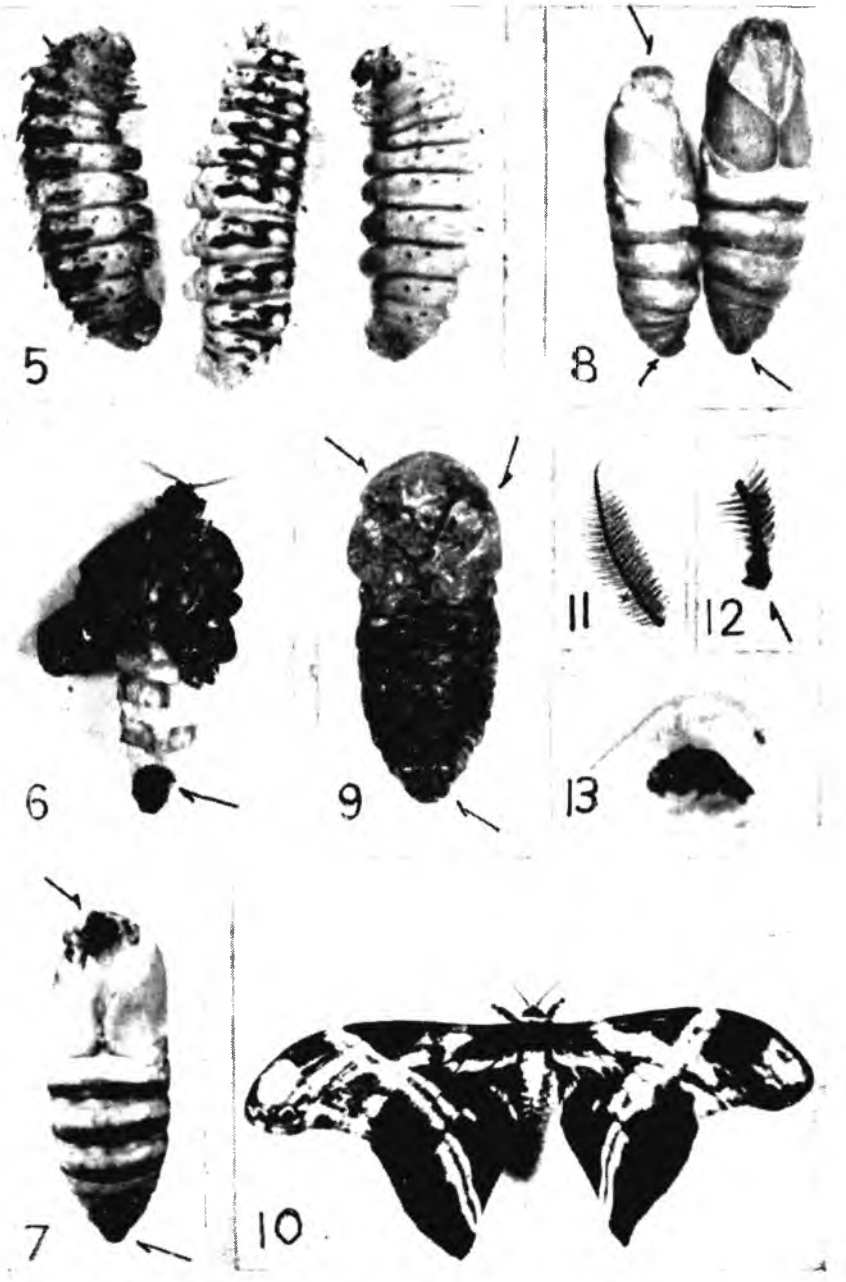


Fig. 1. Normal cocoon thick in texture, well knitted and with one valve. Fig. 2. The cocoons, resulting from the larvae, treated with 25 µl JHA on the day 3. Extremely thin poorly knitted cocoons with two valves. A—anterior valve, P—Posterior valve. Fig. 3. The pupa, taken out from the cocoon of Fig. 4. Note untanned treated parts and abnormal head. The last abdominal segment contains larval characters. Fig. 4. Frontal view of the cocoon showing extremely large and wide (more than 1.5 cm) anterior valve (JH 25 µl dose on 3rd day).

Fig. 5. Larvae (prepupae) of *Philosamia ricini* treated with JHA 12.5 µl on days 3, 4 and 6 survived for 24 days and died without metamorphosis. Fig. 6. An abnormal moth resulting from the larvae treated with JHA 12.5 µl on days 3, 4 and 6. The last abdominal segment contains larval characters. Curly wings also clearly seen. Fig. 7. A pupa resulting from the larvae treated with JHA 12.5 µl on days 3, 4 and 6 showing retention of larval head (arrow) and untanned body parts. Fig. 8. Naked pupae (formed without cocoon) resulting from the larvae treated with JHA 12.5 µl on day 3. Treated part during larval life in pupae is untanned. The last abdominal segment retains larval characters (arrows). Fig. 9. Pupa, taken out from a cocoon resulting from larva treated with 12.5 µl JHA on days 3, 4 and 6. Note abnormal head, wing pads, thoracic legs, the abdomen still contains larval prolegs and other larval characters. Fig. 10. A male moth from the control, showing normal features; Fig. 11. The antenna of a control moth. Fig. 12. Antenna of a moth resulting from the larvae treated with JHA 12.5 µl for 3 days shows many abnormalities bulbous base and rachis. Fig. 13. Antenna of a moth resulting from the larva treated with JHA 12.5 µl for day 3, one antenna is extremely abnormal leaf like.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as a result of JHA treatment has been reported for a number of insects (AKAI & KOBAYASHI, 1971; RIDDIFORD, 1972) as observed in the present work.

SEHNAL & SCHNEIDERMAN (1973) have found in *Galleria* larvae that the terminal portions of the entire last larval prolegs either retained their larval form or assumed a shape intermediate between larva and pupa. In the present work retention of the prolegs in tne abdomen, larval characters in the last abdominal segment, abnormal and/or larval head and head appendages including mouth parts and antennae as well as abnormal wings were clearly seen in the moths resulting from JHA treated larvae.

SLAMA *et al.* (1974) remarked that in many of the insects, JHA treatment never followed by a supernumerary larval moult. The usual effect of JHA on last larval instar of insects is characterised by a delay of pupation.

In the JH treated *Philosamia* larvae, in addition to prolongation of larval duration, either they spinned extremely thin cocoon with 2-abnormal wide valves, or pupated without constructing cocoons (naked pupae). RIDDIFORD (1972) has remarked that at east 5 of the 15 treated animals spun very thin cocoons with abnormally large valves. Further the naked pupae were extremely fragile and the treated parts of the cuticle were devoid of pigmentation. Thus JHA applications also inhibited the tanning of the cuticle in the subsequent moult (i.e. pupae). In *Manduca sexta* also the presence of JH, inhibited melanization of the cuticle and pigment formation occurs only in the absence of JH (TRUMAN *et al.*, 1973).

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CYTOGENETICAL STUDIES ON APHIDS (HOMOPTERA : APHIDIDAE) FROM INDIA : I. KARYOMORPHOLOGY OF EIGHT SPECIES OF *APHIS*

A. R. KHUDA-BUKHSH & N. B. PAL

Department of Zoology, University of Kalyani, Kalyani, W. Bengal, India 741 235

(Received 5 August 1984)

The diploid number, morphhology and behaviour of somatic chromosomes in embryos of apterous viviparous females of eight species of *Aphis*, viz., *A. nerii*, *A. gossypii*, *A. verbasci*, *A. spiraecola*, *A. affinis*, *A. clematidis*, *A. ruborum longisetosum* and *A. fabae solanella*, have been studied. All the species have diploid number of 8 chromosomes. An arbitrary classification of chromosomes has been suggested on the basis of the relative percentage values of individual chromosome pairs and all the eight species had accordingly the chromosome formula of n = 1L (Long) + 2M (Medium) + 1S (Short) chromosomes. Attempts have been made to make out cytological differences among the species by analyzing their idiograms prepared from the morphometrical data of chromosomes and the possible mechanism of karyotypic evolution in this genus has been suggested.

(Key words: chromosomes, karyotypes, aphids, *Aphis*, mitotic behaviour, holokinetic chromosomes)

INTRODUCTION

Out of about 4000 species of aphids taxonomically recorded throughout the globe, only about 550 odd species have so far been cytologically studied including some odd species from India. So far about 700 species of aphids are taxonomically known from India which means slightly over 11% of the Indian aphids have hithertofore been cytologically investigated. This initiated the present investigation.

The present communication deals with the diploid number, mitotic behaviour and morphometrical analysis of somatic chromosomes in eight species of *Aphis*, of which three species, namely, *A. verbasci*, *A. clematidis* and *A. fabae solanella*, do not seem to have been cytologically investigated earlier.

MATERIALS AND METHODS

Embryos were dissected out by squeezing the abdomen of the apterous viviparous females of the eight species of *Aphis*, viz., *A. nerii* Boyer de Fonscolombe, *A. gossypii* Glover, *A. verbasci* Schrank, *A. spiraecola* Patch, *A. affinis* del Guercio, *A. clematidis* Koch, *A. ruborum longisetosum* Basu and *A. fabae solanella* Theobold. Specimens were collected from various host plants and localities (Table 1). The early embryos were subjected to the citrate-airdrying-Giemsa stain schedule (KHUDA-BUKHSH & PAL, 1984a) for the cytological preparations. The diploid number was determined from the count of at least 50 well-spread metaphase complements in each species. The chromosomes in a complement were measured and those of more or less identical lengths were matched as homologous pairs. The relative percentage lengths (R_L) of each pair in the complement were obtained from the mean value of ten complements (Table 2) and the idiograms (Figs. 14–21) were prepared on the basis of their R_L. Further, an arbitrary classification has been made by

TABLE 1. List of species, their host plants, dates and place of collection.

Name of the species	Host plants & families	Place of collection	Date
Aphis nerii Boyer de Fonscolombe	*Rumex* sp. (Polygonaceae)	Trijuginarayan, G. H.	11.10.79
A. verbasci Schrank	*Lantana camara* (Verbenaceae)	Kalyaani, W. B.	9.1.82
A. gossypii Glover	*Erobtorys japonica* (Rosaceae)	Srinagar, J. & K.	1.6.81
A. spiraecola Patch	*Prunus sylvestris* (Rosaceae)	Jamunetri, G. H.	5.10.81
A. affinis del Guercio	*Rubus ulmifolius* (Rosaceae)	Srinagar, J. & K.	3.6.81
A. clematidis Koch	*Clematis buchaniana* (Ranunculaceae)	Sonproyag, G. H.	25.5.80
A. ruborum longisetosnm Basu	*Rubus ellipticus* (Rosaceae)	Srinagar, J. & K.	3.6.81
A. fabae solanella Theobald	*Solanum* sp. (Solanaceae)	Trijuginarayan, G. H.	23.5.80

W. B. = West Bengal; G. H. = Garhwal Himalayas; J. & K. = Jammu & Kashmir

TABLE 2. Mean lengths and relative percentage lengths (R_L) of chromosomes expressed as haploid set in eight species of *Aphis*.

Name of the species	Serial number of chromosomes							
	1		2		3		4	
	Mean length (μm)	R_L	Mean length (μm)	R_L	Mean length (μm)	R_L	Mean length (μm)	R_L
Aphis nerii	4.41	35.11	3.39	26.99	2.75	21.89	2.01	16.00
SE ±	0.59	(L)	0.62	(M)	0.37	(M)	0.34	(S)
A. gossypii	7.64	33.28	6.24	27.18	5.42	23.61	3.65	15.90
SE ±	0.85	(L)	0.48	(M)	0.44	(M)	0.54	(S)
A. verbasci	5.61	32.46	4.50	26.04	4.14	23.95	3.03	17.53
SE ±	0.43	(L)	0.28	(M)	0.29	(M)	0.24	(S)
A. spiraecola	7.78	33.27	6.34	27.11	6.05	25.87	3.21	13.72
SE ±	0.20	(L)	0.27	(M)	0.06	(M)	0.30	(S)
A. affinis	5.01	30.34	4.42	26.77	4.05	24.53	3.03	18.35
SE ±	0.30	(L)	0.20	(M)	0.14	(M)	0.04	(S)
A. clematidis	4.20	31.34	3.74	27.91	3.19	23.80	2.27	16.94
SE ±	0.25	(L)	0.22	(M)	0.21	(M)	0.14	(S)
A. ruborum longisetosum	7.01	34.12	6.00	29.21	5.04	24.53	2.49	12.12
SE ±	0.95	(L)	0.74	(M)	0.55	(M)	0.21	(S)
A. fabae solanella	4.58	32.66	3.84	27.38	3.22	22.96	2.38	16.97
SE ±	0.28	(L)	0.23	(M)	0.21	(M)	0.16	(S)

L = Long; M = Medium; S = Short

suggesting the chromosomes having R_L values above 40% as very long (VL), those having R_L values between 30% and 40% as long (L), those between 20% and 30% as medium (M), those between 10% and 20% as short (S) and those having R_L values less than 10% as very short (VS). This arbitrary nomenclature has been suggested as i) the aphid chromosomes are devoid of any primary constriction, ii) each species could be given a chromosome formula which would enlighten us about the general karyotypic pattern at a glance and iii) a uniformity in description of karyotypes in aphids could be maintained by aphid cytogeneticists.

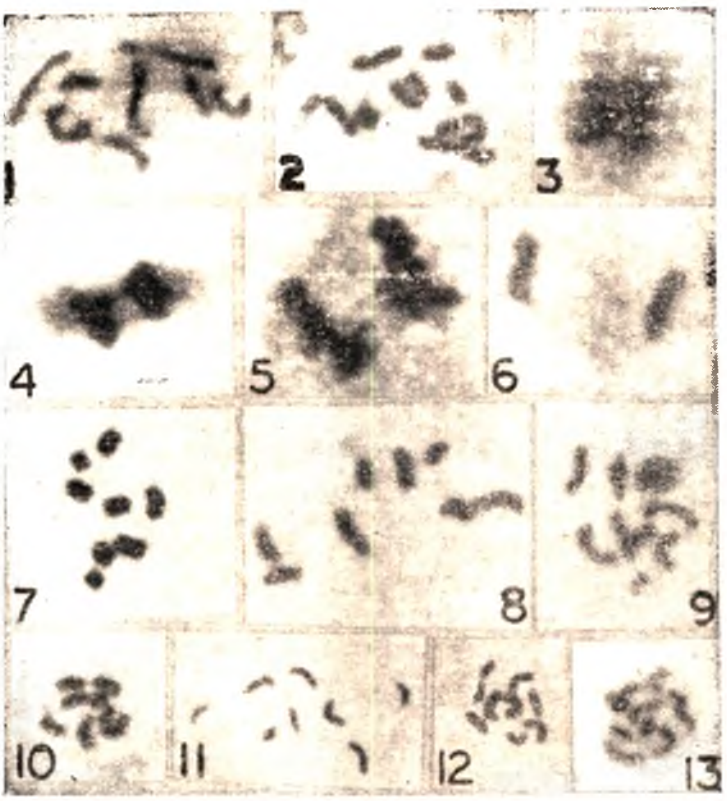
RESULTSS

Mitotic behaviour: Mitotic behaviour in all the eight species of *Aphis* under study followed the same orthodox pattern, and thus the same described hereunder in *A. nerii* would stand for others as well.

The interphase nuclei in *A. nerii* were practically optically empty except for the occasional presence of one or two deep-stained masses. At prophase, intermingled threads with obscure individuality were seen. At prometaphase (Fig. 1), 8 long randomly distributed chromosomes were observed. The chromosomes attained further condensation at mid-metaphase (Fig. 2) when they were used for the morphometrical study. With the progress of metaphase, the chromosomes further condensed and at anaphase (Fig 3), the separated chromatids came together and started moving towards the respective poles in a sheet-like manner indicating their holokinetic nature. However, in a few plates of *A. nerii* only, a sticky-bridge-like configuration (Figs. 4-5) appeared which was not observed in the other seven species of *Aphis*. At telophase (Fig. 6), the separated chromosomes formed a chromatin mass in each pole.

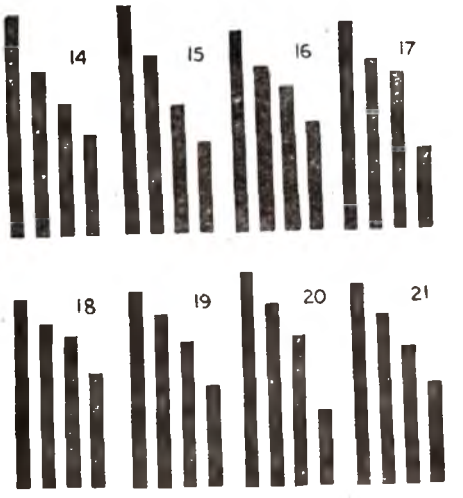
As expected in holokinetic chromosomes, no chromosome showed primary constriction nor was there any longitudinal differentiation.

Chromosome number and morphometrical data: The typical metaphase complements in all the eight species of *Aphis*, namely, *A. nerii* (Fig. 2), *A. gossypii* (Fig. 7), *A. verbasci* (Fig. 8), *A. spiraecola* (Fig. 9), *A. affinis* (Fig. 10), *A. clematidis* (Fig. 11), *A. ruborum longisetosum* (Fig. 12) and *A. fabae solanella* (Fig 13) contained 8 chromosomes. In each species, the chromosome formula could be suggested as n = 1L + 2M + 1S from their R_L values (Table 2) although in some cases the chromosomes appeared to be gradually seriated. The chromosomes from the longest to the shortest measured between 4.41 and 2.01 μm in *A. nerii*, between 7.64 and 3.65 μm in *A. gossypii*, between 5.61 and 3.03 μm in *A. verbasci*, between 7.78 and 3.21 μm in *A. spiraecola*, between 5.01 and 3.03 μm in *A. affinis*, between 4.20 and 2.27 μm in *A. clematidis*, between 7.01 and 2.49 μm in *A. ruborum longsetosum* and between 4.58 and 2.38 μm in *A. fabae solanella* (Table 2). If the R_L values of each chromoseme pair in eight species were compared, some amount of difference could be made out within a narrow range. Thus, they ranged between 35.11% *(A. nerii)* and 30.34% *(A. affinis)* for the 1st pair, between 29.21% *(A. ruborum longisetosum)* and 26.04% *(A. verbasci)* for the 2nd pair, between 25.87% *(A. spiraecola)* and 21.89% *(A. nerii)* for the 3rd pair and between 18.35% *(A. affinis)* and 12.12% *(A. ruborum longisetosum)* for the 4th pairs. The morphometrical data (Table 2) and the idiograms (Figs. 14–21) would reveal that though the pattern of the karyotype was more or less same in all the eight



Figures 1—6. Photomicrographs of chromosome plates from *A. nerii* (× 200. approx.). Prometaphase (Fig. 1), mid-metaphase (Fig. 2), normal anaphase (Fig. 3), anaphase with sticky bridge-like configuration (Figs. 4–5), telophase (Fig. 6). Figures 7—13. Typical metaphase compliments in *A. gossypii* (Fig. 7), *A. verbasci* (Fig. 8), *A. spiraecola* (Fig. 9), *A. affinis* (Fig. 10), and *A. fabae solanella* (Fig. 13).

species, the chromosome lengths differed to some extent among them. The more striking difference in size between the 3rd and 4th pairs of chromosomes was in *A. spiraecola* (Fig. 17) and *A. ruborum longisetosum* (Fig. 20) while it was not so palpable in the other six species. Similarly the difference in size between the 1st and 2nd pairs in *A. nerii* (Fig. 14) was more appreciable in comparison to the same in other species. On the other hand, the difference in size between the 2nd and 3rd pairs of chromosomes appeared to be somewhat uniform in all the eight species (Figs. 14–21). Therefore, the difference in the morphometrical data of chromosomes could not be of great use in cytotaxonomical evaluation of the different species of *Aphis* in general, although some difference could be drawn between karyotypes in some cases as mentioned above. Thus a further refinement of technique, such as, G-banding, may prove helpful in analyzing more critically the karyotypic differences among the different species of *Aphis*.



Figures 14—21. Idiograms of *A. nerii* (Fig. 14), *A. gossypii* (Fig. 15), *A. verbasci* (Fig. 16) *A. spiraecola* (Fig. 17), *A. affinis* (Fig. 18), *A. clematidis* (Fig. 19), *A. ruborum langisetosum* (Fig. 20) and *A. fabae solanella* (Fig. 21) respectively.

DISCUSSION

Aphis is a large genus comprising nearly 500 recorded species (EASTOP & HILLE RIS LAMBERS, 1976) which infest on diverse hostplants and have the ability to thrive in various climatic conditions. So far, about 50 species of *Aphis* have been cytologically investigated and in all but one species, *A. farinosa* (2n=6), the diploid number is 8 (BLACKMAN, 1980; KHUDA-BUKHSH, 1982; PAL & KHUDA-BUKHSH, 1982). Since the diploid number is so stable in this genus, it would seem that in the evolution of karyotype among the congeneric species of *Aphis* the minute structural rearragements involving fragmentation/fusion of chromosomes, more indicative from the data of the 1st and 4th pairs of chromosomes, could have played a significant role. However, with a view to finding out if any particular pair (s) of chromosomes were more prone to fragmentation and if the breaking points were localized in nature, we (KHUDA-BUKHSH & DATTA, 1981; KHUDA-BUKHSH & PAL, 1984b) subjected *A. gossypii* and *A. nerii* to whole-body X-irradiation and the results did show more breaks to occur in the 1st pair than expected on a random basis indicating that the 1st pair of chromosomes were more fragile than the other pairs in response to the physical mutagen.

Acknowledgements: The authors are grateful to Prof. G. K. MANNA and the Head, Department of Zoology, University of Kalyani for encouragement and laboratory facilities. We are thankful to Dr. D. RAY-CHOUDHURY, Lecturer, Department of Zoology, University of Calcutta, for the identification of the aphid specimens. The financial assistance from the UGC through the University of Kalyani for the work is gratefully acknowledged.

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BRIEF COMMUNICATION

SOME COLEOPTERAN PREDATORS ASSOCIATED WITH TIMBER PESTS IN KERALA (INDIA)

GEORGE MATHEW

Division of Entomology, Kerala Forest Research Institute, Peechi, India 680 653

(Received 30 June 1984)

In a study conducted on the timber pests of Kerala, 16 species of predatory beetles were collected and identified. They belonged to the families, Cleridae, Colydidae, Histeridae, Passandridae, and Tenebrionidae. Timber pests belonging to the families, Bostrychidae, Platypodidae and Scolytidae were found to be attacked.

(Key words: coleopterans, predators, timber pests)

In a recent study conducted in Kerala (MATHEW, 1982), fifty species of timber boring beetles were recorded as pests of various commercially useful stored timbers. The study has also revealed the occurrence of several predatory insects associated with these beetles. They belonged to the families Cleridae, Colydidae, Histeridae, Passandridae and Tenebrionidae. Excepting the family Colydidae, all the remaining families are known to contain predatory species. The insects collected in this study are new to the State and are listed in Table 1.

All the species recorded here were taken from the borer holes of the respective timber pest. The predatory habit of these insects was suggested by their presence in host tunnels. Published information on the habits of each species corroborate the predatory habit (BEESON, 1941; STEBBING, 1914). All the insects were identified by referring to experts in the Commonwealth Institute of Entomology, London.

Of the 16 species collected here, *Tarsostenus univittatus* (Cleridae), *Teredolaemus similis* (Colydidae), *Teretriosoma* sp. *Trypanaeus bombacis, T. (Trypeticus) indicus*, (Histeridae), *Cryphaeus* sp. and *Coelopalorus carinatus* (Tenebrionidae) attack platypodid borers. *Diaclina* sp. *Drapetes* sp. and *Palorus cerylonoides* mostly predate on scolytids. The bostrychid borers are prayed upon by *Tillus notatus* (Cleridae), *Hectarthrum heros*, *Laemotmetus insignis* (Passandridae), *Lyphia orientalis*, *Palorinus humeralis* and *Latheticus oryzae* (Tenebrionidae). Borers belonging to the families Bostrychidae, Platypodidae and Scolytidae are a major threat for the successful storage of several species of commercially important timber in Kerala. The role of predatory beetles in timber pest management requires further study.

Acknowledgement: I am grateful to Dr. R. MADGE, Dr. T. G. VAZIRANI and Dr. M. L. COX of the Commonwealth Institute of Entomology, London, for identification of insects collected in this study as well as for information on the habits of some of the species collected here.

TABLE 1. List of insects collected in this study.

Predatory beetle	Host insect	Timber species	Locality	Remarks on the predatory insects
Family Cleridae				
1. *Tarsostenus univittatus* (Rossi)	*Platypus solidus*	*Tetrameles nudiflora*	Ollur	Reported to be predaceous on *Lyctus africanus*. *Trogoxylon spinifrons* and *Minthea rugicollis* (Beeson 1941).
2. *Tillus notatus* Klug	*Dinoderus ocellaris*	*Bambusa* spp.	Vellor	Reported to be predatory on species of *Dinoderus, Lyctus, Trogoxylon, Sinoxylon* and *Xylodectus* (Beeson, 1941).
Family Colydidae				
3. *Teredolaemus similis*	*Platypus solidus* *Xyleborus similis* *X. interjectus*	*Persea macrantha* *Erythrina indica* "	Kannoth Mavoor	
Family Histeridae				
4. *Teretriosoma* sp.	*P. latifinis*	*Bombax malabaricum*	Vazhni	
5. *Trypanaeus bombacis* Lewis	*Platypus solidus*	*Holigarna arnotiana*	Manantoddy	Reported to be predatory on Scolytids and Platypodids (Beeson, 1941).
6. *T.(Trypeticus) indicus* Lewis	*Platypus solidus*	*persea macrantha*	Kannoth	
Family Passandridae				
7. *Hectarthrum heros* (Fb.)	*Xylothrips flavipes*	*Veteria indica*	Baliyapattam	Reported to be predatory on the larvae of Cerambycidae, Curculionidae and Bostrychidae (Beeson, 1941).
8. *Laemotmetus insignis* Grouv.	*Sinoxylon anale*	*Lagerstroemia* sp.	Peechi	Reported to be predatory on *Dinoderus* and *Lyctus* beetles (Beeson, 1941).
Family Tenebrionidae				
9. *Cryphaeus* sp.	*Platypus solidus*	*Mangifera indica*	Mundakayam	
10. *Coelopalorus carinatus* (Blair.)	*Platypus solidus*	*Persea macrantha*	Kannoth	
11. *Diaclina* sp.	*Xyleborus interjectus*	*Artocarpus heterophyllus*	Ollur	
12. *Latheticus orygzae*	*Sinoxylon conigerum*	*Ceiba pentandra*	Baliyapattam	Reported to be predatory on *Dinoderus bifoveolatus* and *Sinoxylon pygmaeum*
13. *Lyphia orientalis* Blair.	*Sinoxylon anale*	*Grewia tiliaefolia*	Always	
14. *Palorinus humeralis* (Gebien)	*Dinoderus ocellaris*	*Ochlandra travancorica*	Vellor	
15. *Palorus cerylonoides*	*Xyleborus similis*	*Hevea brasiliensis*	Ollur	Reported to be predatory on the scolytid genera, *Cryphalus*. *Poecilips* and *Sphaerotrypes* (Beeson, 1941).
16. *Drapets* sp.	*Xyleborus similis* *X. interjectus*	*Zanthoxylum rhetsa*	Vazhachal	

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REPORTS AND NEW RECORDS

NEW RECORDS OF BIO-AGENTS ON SOYBEAN LEAF ROLLERS, *NACOLEIA VULGALIS* GUEN. AND *N. DIEMENALIS* GUEN. IN KHASI HILLS OF MEGHALAYA (INDIA)

N. S. AZAD THAKUR

ICAR Research Complex for NEH Region, Bishnupur, Shillong 13, Meghalaya India 793 013

(Received 9 June 1984)

Eight species of parasites and one species of predator have been recorded parasitizing/predating on larvae pupae of leaf rollers of soybean in Khasi Hills of Meghalaya (India)

(Key words: Nacoleia vulgalis Guen. and *N. diemenalis* Guen. parasites & predator)

The leafroller, *Nacoleia vulgalis* Guen. and *N. Diemenalis* Guen: (Pyralidae, Lepidoptera) are serious pests from July to September, causing considerable damage to soybeen crop in Khasi hills of Meghalaya (SACHAN & GANGWAR 1980). During survey conducted at weekly interval from second week of July to end of September 1983, the following parasites/predators have been recorded. There is no record of any of these parasites on the pest from India though elasmid, *Elasmus indicus* Rohwer and Ichneumonid, *Xanthopimla punctator* (Linnaeus) were recorded from *Lamprosoma indicata* (B) from this country. However, a chalcid fly, *Brachymeria* sp. and an Ichneumonid fly, *Xamthopimla punctata* Fabr. were found to parasites both the species of soybean leaf rollers, *Lamperosoma diemenalis* Guenes. and *L. indicata* (Fab.). (BHATTACHARJEE, 1976)

The extent of parasitization ranged from 18 to 21.50 per cent with a mean of 19.47 per cent, which is quite high. Based on extent of parasitization, these bio-agents can be employed in integrated pest management programme. The above parasites/predators have been recorded for the first time on this insect from Khasi Hills of Meghalaya (India).

Acknowledgement: The auther is thankful to Dr. D. N. BORTHAKUR, Director ICAR Research Complex for NEH region, Shillong for providing necessary facilities and encouragement and to Director Commonwealth Institute

Parasite	Order	Family
Gonniozus sp.	Hymenoptera	Bethylidae.
Trichomalopsis apanteloctena (Crawford)	Hymenoptera	Pteromalidae
Apanteles sp. *(Ater* species group)	Hymenoptera	Braconidae.
Apanteles sp. *(Ultor* species group)	Hymenoptera	Braconidae.
Phanerotoma sp.	Hymenoptera	Braconidae.
Bracon sp.	Hymenoptera	Braconidae.
Orgilus sp.	Hymenoptera	Braconidae.
Sarcophaga sp.	Diptera	Sarcophagidae.
Predator		
Cantheconidea furcellata (Wolff)	Heteroptera	Pentatomidae.

of Entomology, London for determination of the parasite and predators.

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RECORD OF A NEW MEALY BUG, *PERISSOPNEUMON FEROX* NEWSTEAD (MARGARODIDAE : HOMOPTERA) ON MANGO FROM UTTAR PRADESH, INDIA

R. P. SRIVASTAVA* & ABRAHAM VERGHESE

Central Institute of Horticultural Research, Mahanagar, Lucknow 226 006

(Received 30 June 1984)

Heavy infestation of a mealy bug *Perissopneumon ferox* Newstead, on mango for the first time was seen in Tikkapurwa.

(Key words: mealy bug, *Perissopneumon ferox* Newstead, mango)

Heavy infestation of a mealy bug ***Perissopneumon ferox*** Newstead, on mango was seen in an orchard in Tikkapurwa, a village of Lucknow district in 1980. This is the first record of this pest on mango. The biology of the mealy bug was observed in field during 1981 and 1982. The adult wingless female deposited the eggs in soil during June-July, which hatched by the middle of April, after diapausing for nine to ten months. The first instar nymphs crawled up the tree by the end of April, and eventually settled on the inflorescence, fruit stalk and some on the fruits too (Fig. 1). The feeding of nymphs by sucking the sap caused fruit drop (Fig. 1). Three instars were noticed spanning to about 50–60 days. It was observed that by fastening 400 gauge, 30 cm wide alkathene bands around the tree trunk, one foot from the ground, the ascent of the mealy bugs up the three could be prevented.

Two predators, *Rodalia fumida* Muls. (Coccinellidae : Coleoptera) and *Leptus* sp. (Erythracidae : Acarina) were seen preying on *P. ferox* and are new records on it.

Thanks are due to Dr. D. J. WILLIAMS of the Commonwealth Institute of Entomology, London, for identifying the mealy bug.

* Present Address: Department of Entomology, Indian Institute of Sugarcane Research, Lucknow.

Fig. 1. Mango fruit stalk infested with *Perissopneumon ferox*. To the left is an empty stalk from which fruit has fallen.

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BOOK REVIEW

INSECTS IN VEGETABLES, by DHAMO K. BUTANI & M. G. JOTWANI, Periodical Expert Book Agency, Delhi, 1984, 356 pp Rs. 150/$ 30.

The book written by two eminent authorities in this field, deals exhaustively with the insect pests on almost all vegetables in India: brinjal, tomato, chillies okra, curcurbits, beans, peas, drumstick, amaranthus, spinach, salad and cole crops, potato, sweetpotato, arum (colocasia), yam, amorphophalus, rootcrops (raddish, carrot, turnip, beetroot) and onion. Mites and nematodes which attack the crop have also been included. Treatment is cropwise and hence necessarily there is some unavoidable repetition and the authors have made every effort to keep this minimum to the extent possible. The account on each pest includes a brief survey on distrition, identifying characters, life history, biology, damage caused, control methods etc. The book is well illustrated with about 200 figures, including colour plates. There is a section on general aspects of pest control which also includes residue problem in its various aspects; plant protection equipments as well as equipments for residue analysis have also been illustrated. There is an exhaustive bibliography of about 600 references, which is up-to-date and quite useful; this is followed by a convenient classified list of pests which includes the crops which each pest species attacks; the glossary comprises many botanical terms also. This is followed by an index of insect species. There is no doubt that the book (hard bound) with a beautiful colour jacket, will be quite useful to undergraduates a swell as to post-graduates including many research workers, both basic scientists and applied entomologists who deal with agricultural pests. However, spelling mistakes are too numerous and could have been avoided; careful editing could have improved the book. On the whole the book is an asset to entomological literature, especially to Indian Entomology.

V. K. K. Prabhu

ANNOUNCEMENTS

National Symposium on Insect Physiology, Ecology and behaviour

The Association fo: Advancement of Entomology proposes to organise a Symposium on diverse aspects covering Physiology, Ecology and Behaviour of different insect groups from 15th to 17th January 1985, at Trivandrum. Details regarding the Symposium can be had from Dr. D. Muraleedharan, Covener, Symposium on Insect Physiology, Ecology & Behaviour, Department of Zoology, University of Kerala, Kariavattom - 695 581.

Second National Symposium on Recent Trends in Aphidological Studies

A four day, Second National Symposium on Recent Trends in Aphidological Studies, sponsored by the University Grants Commission will be held at Department of Zoology, M. M. Post Graduate College, Modinagar - 201 204, under the auspices of Meerut University to discuss the different aspects of Aphid Study, from September 26 to 29, 1985. Abstracts of the papers in duplicate may be sent to the convener of the symposium by 15th June, 1985 and the full paper by 15 July, 1985. For further details please write to: Dr. S. P. Kurl, Convener, Second National Symposium on Recent Trends in Aphidological Studies, Department of Zoology, M. M. Post Graduate College, Modinagar - 201 204.

All-India Symposium on Recent Trends in Insect Endocrinology

An All-India Symposium on Recent Trends in Insect Endocrinology sponsored by University Grants Commission, New-Delhi is scheduled to be held from 9th Sepetember to 12th Sepetember 1985 at the Department of Zoology, Government College, Ajmer under the Directorship of Shri. J.N. Mathur.

The Symposium shall have a few major scientific sessions and invited lectures on the important themes. Papers on any branch of Insect Endocrinology are welcome. The abstracts of contributions and full text of the presented papers are proposed to be published.

For further details please contact Dr. Sudhir Bhargava, Symposium-Secretary, Recent Trends in Insect Endocrinology, Department of Zoology, Government College, Ajmer 305 001, Rajasthan. Last date for receipts of abstract is August 1, 1985.

National Conference on Key Pests of Agricultural crops

A National Conference on Key Pests of Agricultural Crops is being organised at C. S. Azad Uuiversity of Agriculture & Technology, Kanpur from Deeember 21—23, 1985. For details please contact Dr. Y. K. Mathur, Professor & Head (Entomology) and Organising Secretary, National Conference on Key Pests of Agricultural Crops, C. S. Azad University of Agricultue & Technolog Kanpur-208 002.

Second National Syposium on Pesticide Residues and Environmental Pollution

The Second National Symposium on Pesticide Residues and Environmental Pollution is proposed to be held from 2—4 October 1985 in the PG Department of Zoology, Sanathan Dharm College, Muzaffarpur 251001. Typed Abstrrcts in duplicate (250 words) invited so as to reach the convener by July 31, 1985. Contract Persons : Dr. L. N. Mittal (Chairman)/Dr. S. C. Goel (Convener).

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ENTOMON is covered in the following abstracting/indexing journals : *Chemical abstracts* (Chemical Abstracts Service, The Ohio State University, Columbus, Ohio 43210, U. S. A.), *Review of Applied Entomology* (Commonwealth Institute of Entomology, 56 Queen's Gate, London SW9 5JR, England), *Science Citation Index* and *Current Contents Agriculture, Biology & Environmental Sciences* (Institute of Scientific Information, 3501 Market Street, Philadelphia, Pa. 19103, U.S.A.), *Biological Abstracts* (Biosciences Information service, 2100 Arch street, Philadelphia, Pa. 19103, U. S. A.), *Entomology Abstracts* and other relevant *Abstracts* (Information Retrieval Limited, 1 Falconberg Court, Lodon WIV 5FG, England), *Referativnyi Zhurnal* (The Institute of Scientific Information, Academy of Science of the U. S. S. R., Baltijskaya ul., 14, Moscow A—219, U. S. S. R.), *Current Advance in Biological Sciences*, 132 New Walk, Leicester LEI 7QQ, England

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